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JPRS Report

Science & Technology

Central Eurasia: Space

Science & Technology
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JPRS-USP-92-001 CONTENTS *27 January 1992*

Notice to readers: The name of this book will change from "USSR: Space" to "Central Eurasia: Space" as of 6 Jan 92.

Interplanetary Sciences

Space Engineering

Space Applications

Space Policy, Administration

Ukraine Planning Manned Spaceflight

PM1811143391 Moscow IZVESTIYA in Russian 16 Nov 91 Union Edition p 1

[Unattributed report from the "IZVESTIYA, TASS, RIA, INTERFAX" roundup]

[Text] The Ukraine is preparing its own space expedition. As Supreme Soviet Chairman L. Kravchuk reported at a meeting with voters in Zaporozhye, a national crew should take off next summer. It will conduct scientific research in the interests of the sovereign Ukraine.

Mir Cosmonauts Continue Research Experiments

LD2311041591 Moscow TASS in English 1829 GMT 22 Nov 91

[By TASS correspondent from Mission Control Center]

[Text] Moscow November 22 TASS—The 130-hour technological process of raising a monocrystal of semiconductive cadmium sulphide material in the "Crater-B" electric heating furnace has completed today at the Mir orbiting station.

This week Aleksandr Volkov and Sergey Krikalev conducted geophysical and astrophysical studies.

In particular, they used the "Priroda-5" photographic complex and the KAP-350 topographic installation to film the earth surface.

The cosmonauts have also prepared the "Roentgen" international orbiting observatory, and made a check-up observation of the Lebed [Cygnus] X-1 Roentgen source.

The crew used the "Volna-2" to continue its experiments on testing elements of fuel systems of new spacecraft in flight conditions.

'Gamma'Astronomy Satellite

927Q0014 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 91 pp 2-9

[Article by P. N. Polezhayev, lead designer at NPO Energiya, and V. P. Poluektov, candidate of technical sciences and sector chief at NPO Energiya, under the rubric "The Space Program": "Space-Based 'Gamma' Observatory"; first paragraph is source introduction]

[Text] **On 11 July 1990, the Soviet space-based Gamma observatory was launched. Gamma was designed to conduct basic research in the field of gamma astronomy. Despite malfunctions in the operation of the science gear, the observatory has managed to obtain new, important experimental data. How is the observatory put together? What instruments and science gear is it outfitted with?**

The study of cosmic gamma rays is one of the most important areas of astronomy and astrophysics today (ZEMLYA I VSELENNAYA, 1973, No 1; 1981, Nos 3 and 4). Such research can only be done from the orbit of an artificial Earth satellite, because the Earth's atmosphere absorbs virtually all the primary cosmic gamma radiation. The greatest amount of information on cosmic gamma rays with energies in the hundreds of MeV has been given to us by a European satellite (COS-B), which was in orbit in the late 1970s. Since then, no broad experiments have been conducted in the field of cosmic gamma astronomy. And now, at last, in our country, a new science instrument package and a new specialized module have been created. By comparison with the COS-B satellite, the space-based Gamma observatory and the science instrument package it carries were to have a sensitive area several times bigger and an angular resolution 3-4 times better; the Gamma observatory was to cover a large range of the electromagnetic spectrum—10^4-10^{10} eV.

The final look of the observatory had been decided upon by 1980. The science instrument package included the Gamma-1 telescope, with a Telezvezda star tracker; the Disk-M telescope; and the Pulsar X-2 telescope.

The observatory is designed to stay aloft at least one year, in a circular orbit (altitude 350-400 km, inclination 51.6°).

Design of the Observatory

The Gamma observatory consists of five compartments. Inside the large compartment of the science instrument package is the Gamma-1 telescope. The two other telescopes—the Disk-M and the Pulsar X-2—are on the exterior surface of the small compartment of the science instrument package. The primary service systems are located in the instrument compartment of the observatory, and the vernier propulsion system is located in the equipment compartment. On the outside the transfer compartment are two solar panels (one set on the port side and one on the starboard).

To be able to function for a lengthy period of time in orbit, the observatory has more than 10 service systems that are consolidated into a single onboard complex. Those systems include the control-of-motion system, the navigation system, the power supply system, the radio communications system, the telemetry system, and the temperature-control system. Control of the service systems and the science instrument package is effected with a general control system for the onboard complex.

The control system for the onboard complex (CSOC) comprises automatic units (based on microprocessor hardware), a program and timing unit, automatic power units, and the onboard timekeeping unit. The CSOC controls the observatory automatically via assigned programs. A control program is assembled several orbits ahead of time in the form of a combination of "rigid" and "flexible" programs. The flexible programs are used, as a rule, for turning rigid programs on and for issuing the necessary one-time commands. In order to support the operation of the science instrument package, the CSOC uses six rigid programs and as many as 200 one-time commands. Stability of onboard current time is 10^{-8} sec. That enables scientific measurements with an accuracy of reference to the timekeeping system of no worse than 1 msec.

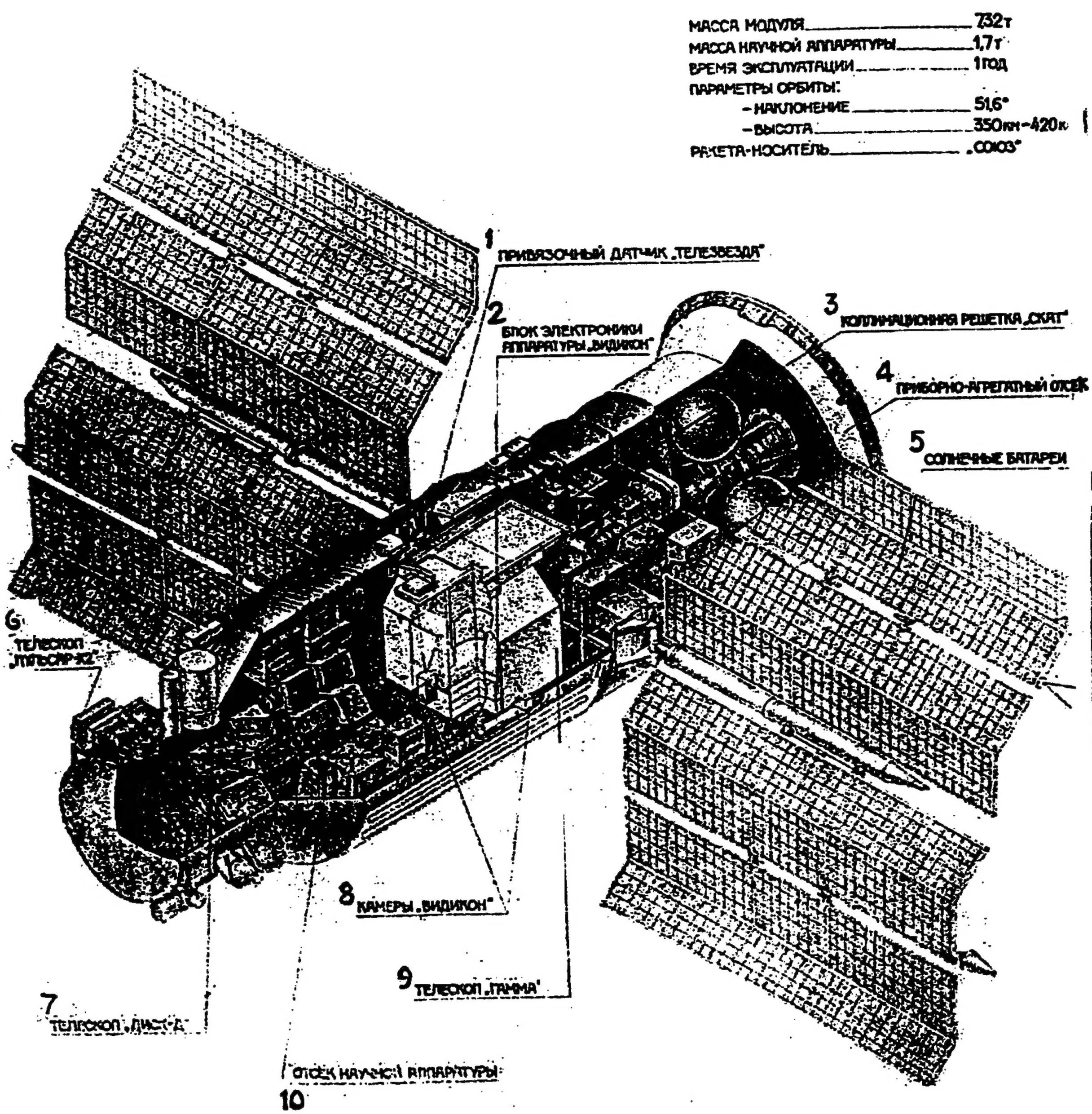
The control-of-motion system (CMS) effects all the necessary movements of the observatory in space. Attitude control is performed with navigational sun seekers and star trackers and local vertical sensors. End effectors are powered gyroscope-gyrodynes that make it possible to point the observatory in a given direction and hold it there with virtually no expenditure of rocket propellant. The operation of the CMS is controlled by an onboard computer. The principal dynamic characteristics of the attitude control mode are amplitude of autooscillation 3' and angular velocity of autooscillations up to 0.3 arc min/s. The CMS makes it possible to point and hold the telescope with an accuracy of 10-30'. During actual operation of the observatory, it has turned out to be possible on every orbit to observe two sectors of the celestial sphere. That has almost doubled the available amount of scientific measurements (the coefficient of effective use of time per orbit is as high as 85 percent).

A combined propulsion system with a 300 kgf sustainer engine is used to compensate for the steady lowering of the orbit. When the engine is in operation, the observatory is stabilized by swiveling its combustion chamber and through the use of low-thrust attitude-control engines. The total amount of propellant is 780 kg (that is enough for the observatory to stay aloft for at least one year).

The power supply system (PSS) is based on two solar panels with photoelectric converters. The total area of the panels is 36.5 sq m. The system also includes nickel-cadmium storage batteries and charger and discharger devices that support the joint operation of the storage batteries and the solar panels. The maximum PSS power is 3.5 kW (DC, output voltage 24-34 V). The

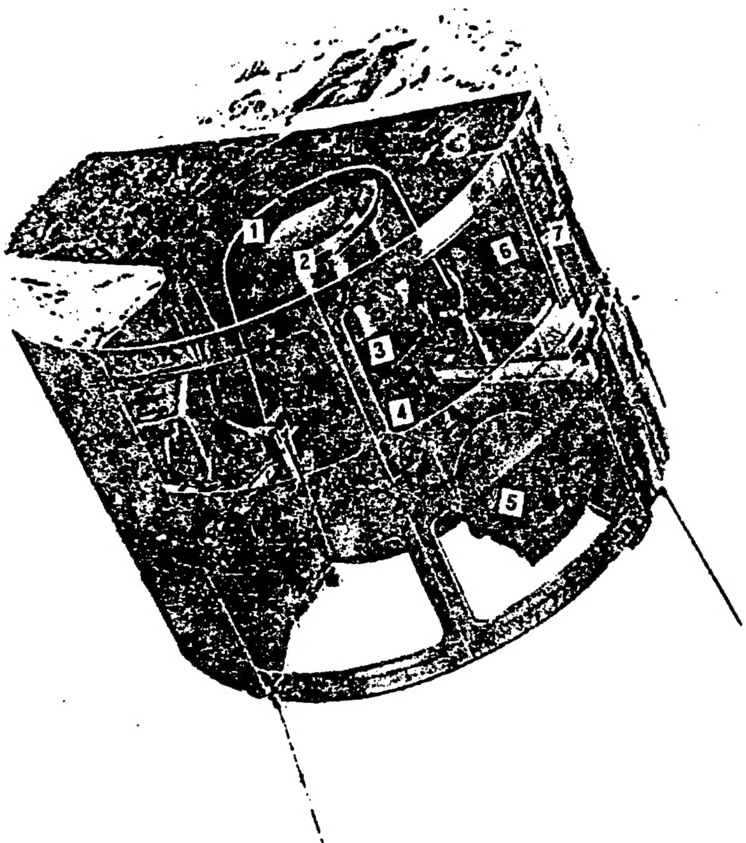
Gamma Astrophysical Research Module

АСТРОФИЗИЧЕСКИЙ ИССЛЕДОВАТЕЛЬСКИЙ МОДУЛЬ „ГАММА"



Gamma specifications: module mass, 732 tons; science instrument package mass, 1.7 tons; operational life, 1 year; orbital inclination, 51.6°; orbital altitude, 350-420 km; launch vehicle, Soyuz

Key: 1. Telezvezda star tracker—2. Vidikon electronics—3. SKAT collimation grid—4. Instrument-equipment compartment—5. Solar panels—6. Pulsar X-2 telescope—7. Disk-D [*sic*] telescope—8. Vidikon camera—9. Gamma telescope—10. Science instrument package compartment



European COS-B gamma satellite

Key: 1. Detectors—2. Spark chambers—3. Telescope—4. Calorimeter—5. Gas container—6. Electronics—7. Solar panels (The mass of the satellite was 278 kg, and the mass of the science instrument package, 118 kg)

solar panels are equipped with electromechanical drives that ensure uniaxial orientation of the panels toward the Sun. The error in pointing to the Sun along that axis is no greater than 6°, which enables a maximal energy output by the solar panels.

The temperature-control system (TCS) is configured with circulation of air in the pressurized compartments of the observatory, and thermostatting of the instrument locations in the nonpressurized compartments. The heat given off by the instruments is transferred in a stream of air to the general heat-exchanger, from where it is removed to an outer radiating element.

The air temperature is kept in range of 0-40°C in the compartments and the instrument locations and 0-30°C in the science instrument package working areas. Atmospheric pressure is 450-980 mm Hg.

The telemetry system (TS) supports collection of scientific and service information, storage of that information, and it's transmission to Earth. The scientific information goes from the observatory to Earth in the form of digital files—one or two times a day. The largest possible amount of daily information is 120 Mbits. The rate at which the digital files are transmitted into the telemetry system can reach 170 kilobits per second.

Some of the onboard service systems of the Gamma observatory have already undergone a lengthy debugging on the Progress and Soyuz spacecraft and the Mir orbital station. That not only makes for the high degree of operational reliability of those systems, but also reduced the cost of creating the Gamma observatory considerably.

Just before the flight of the observatory, its structure underwent comprehensive ground-based strength tests, the temperature conditions were fine-tuned in large altitude chambers that simulated actual conditions of space flight, and individual and combined electrical tests were done for all the service systems and the science instrument package.

Science Instrument Package

The Gamma-1 telescope is the observatory's principal science instrument and is designed to perform detailed studies of high-energy gamma radiation (from 50 MeV to 5 GeV).

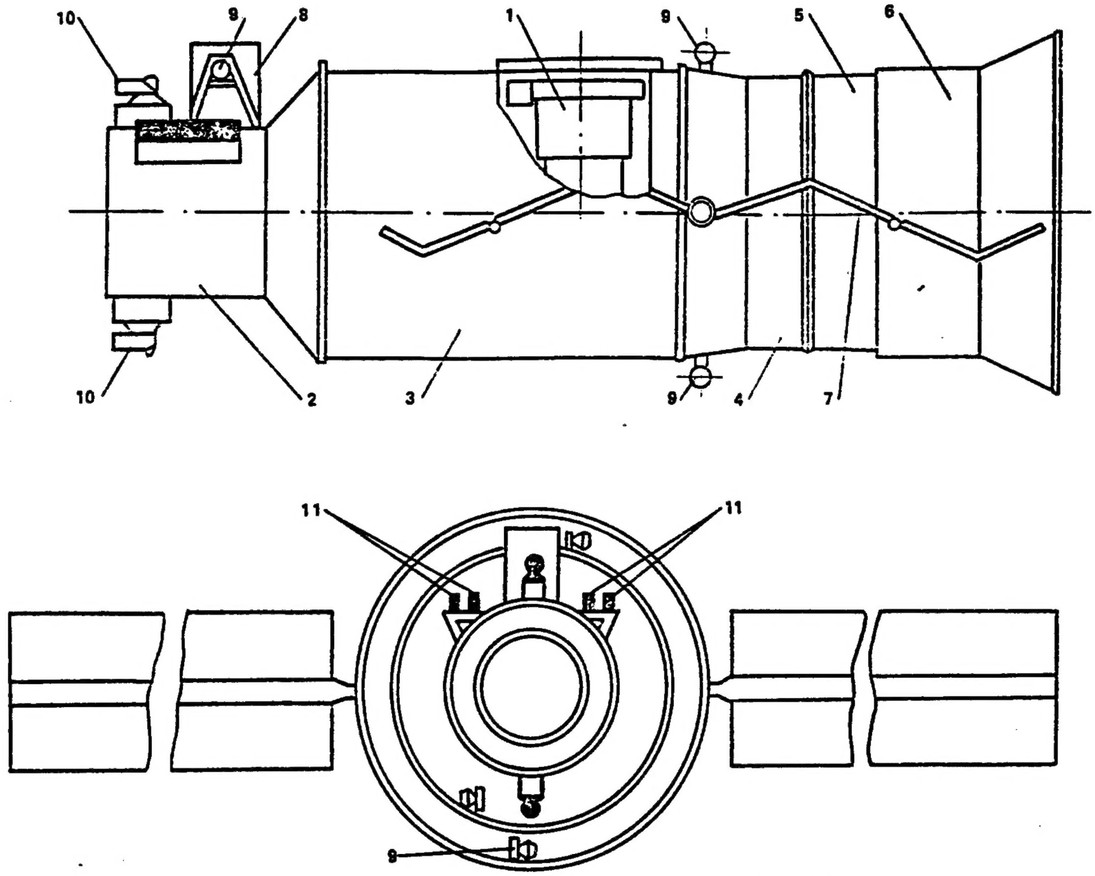


Diagram of spaces for instruments and assemblies on the space-based Gamma observatory

Key: 1. Gamma-1 telescope—2. Science instrument package compartment (small)—3. Science package compartment (large)—4. Transfer compartment—5. Instrument compartment—6. Equipment compartment—7. Solar panels—8. Disk-M telescope—9. Sun sensors—10. Star trackers—11. Pulsar X-2 telescope counters. The length of the observatory is nearly 8 m, the maximum diameter of the hull is 2.7 m, and and the pressurized compartments contain 20 cu m of space.

The telescope comprises the following principal systems:

1. A system consisting of two scintillation counters, a gas Cerenkov counter, and logic-based electronics. When gamma particles that have entered the field of view of those detectors are recorded, the other systems of the telescope are triggered by a signal from this system.

2. A system for protection against the charged particles of cosmic rays consisting of nine scintillation detectors whose work is based on anticoincidences. Five of the detectors form a "cap" over the counters and the spark chambers. Three of the detectors are on the sides of the coding mask. The last detector is on the outside of the science instrument package compartment (it excludes recording of secondary gamma quanta that can form in the material making up the hull of the compartment).

3. Broad-gap spark chambers.

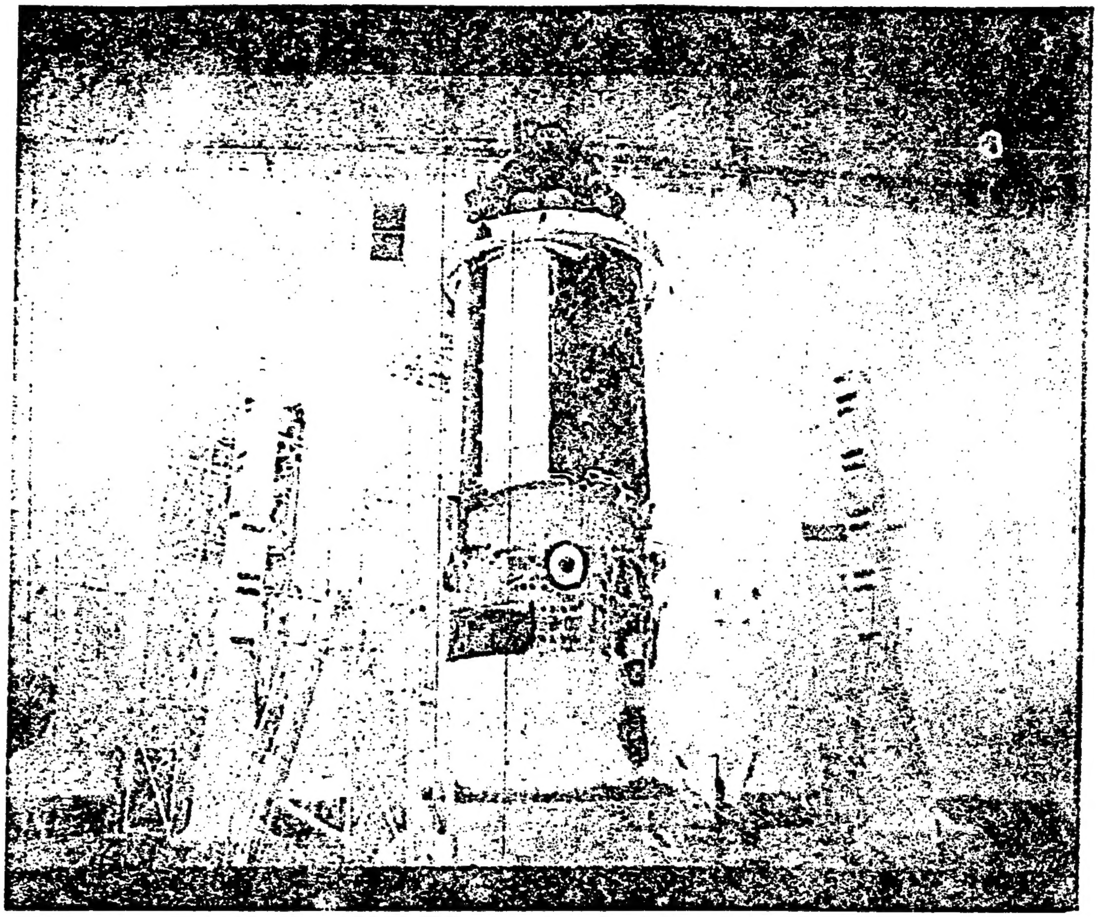
4. A system for scavenging the spark chambers; it produces a constant flow of a specially chosen mixture of Ar, Ne, and CO_2 that is consumed at 7-10 cu cm/min. That is necessary for maintaining the proper degree of cleanliness of the internal portion of the chambers.

5. A system of mirrors and two television cameras for visually recording the tracks of the charged particles.

6. A calorimeter consisting of alternating layers of lead and plastic scintillator. It is designed to measure charged-particle energy.

7. A coding mask made of tungsten plates (1 cm thick) installed below the shell of the science instrumentation package compartment to improve the angular resolution of the telescope (up to 20').

The efficiency of all the telescope systems was checked during ground-based debugging, which included special



Gamma observatory just before combined testing

calibration on beams of labelled gamma quanta (the accelerator in Pakhra near Moscow).

The Gamma-1 telescope was created through the efforts of the USSR Academy of Sciences Space Research Institute, the Experimental Design Bureau of the Space Research Institute, the Moscow Engineering Physics Institute, the NPO [Scientific Production Association] Energiya, the USSR Academy of Sciences Lebedev Physics Institute, and the USSR Academy of Sciences Leningrad Physicotechnical Institute, as well as several French institutions (the Center for Nuclear Research in Sacle, the Center for Research of Cosmic Radiation, and the National Center for Space Research in Toulouse).

The Telezvezda star tracker works together with the Gamma-1 telescope. It has a field of view of 6° X 6°, a fifth-stellar-magnitude sensitivity, and an angular resolution of 2'. That makes it possible to determine the true attitudinal position of the Gamma-1 telescope's axis with the same degree of accuracy. The mass of the star tracker is 18 kg. The tracker was developed and manufactured by Polish specialists.

The Disk-M telescope was designed to measure fluxes of "soft" gamma radiation in the energy range of 20 keV to 5 MeV. The detectors are NaI crystals.

The angular resolution of the telescope is 20-30', and it has sensitivities of 10^{-4} $1/cm^2$ sec (at 200 keV) and 10^{-6} $1/cm^2$ sec (at 2 MeV). The mass of the telescope is 78 kg. The Disk-M telescope was developed and manufactured at the USSR Academy of Sciences Physicotechnical Institute.

The Pulsar X-2 telescope measures x-ray radiation with energies of 2-25 keV (near the region of "soft" gamma radiation). The telescope has a field of view of 10° X 10° and an angular resolution of up to 30'. The mass of the telescope is 50 kg. The telescope was developed and manufactured by the USSR Academy of Sciences Space Research Institute and the French Center for Research of Cosmic Radiation (Toulouse).

All three telescopes are mounted coaxially on the observatory and can simultaneously study a given region of space.

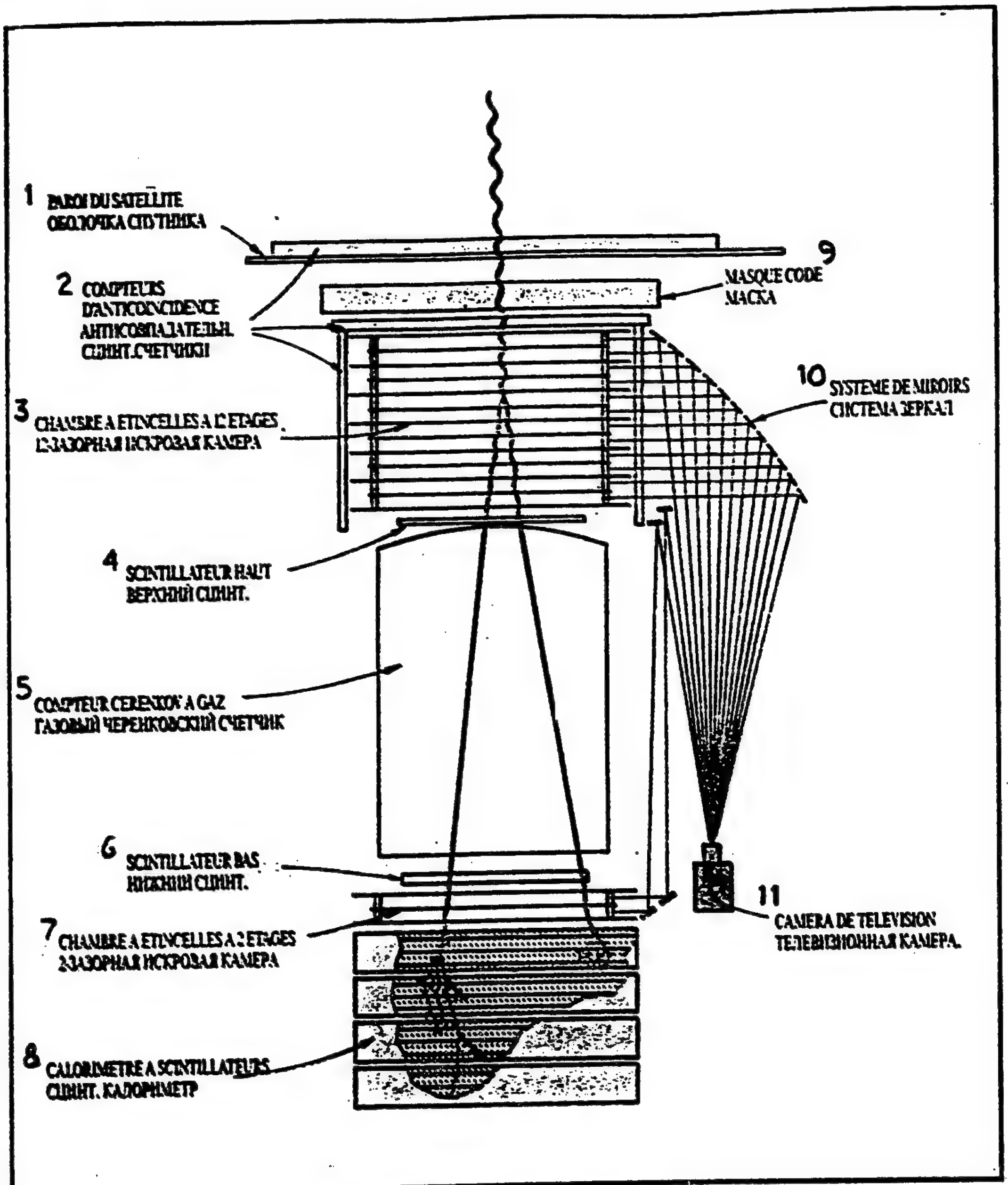


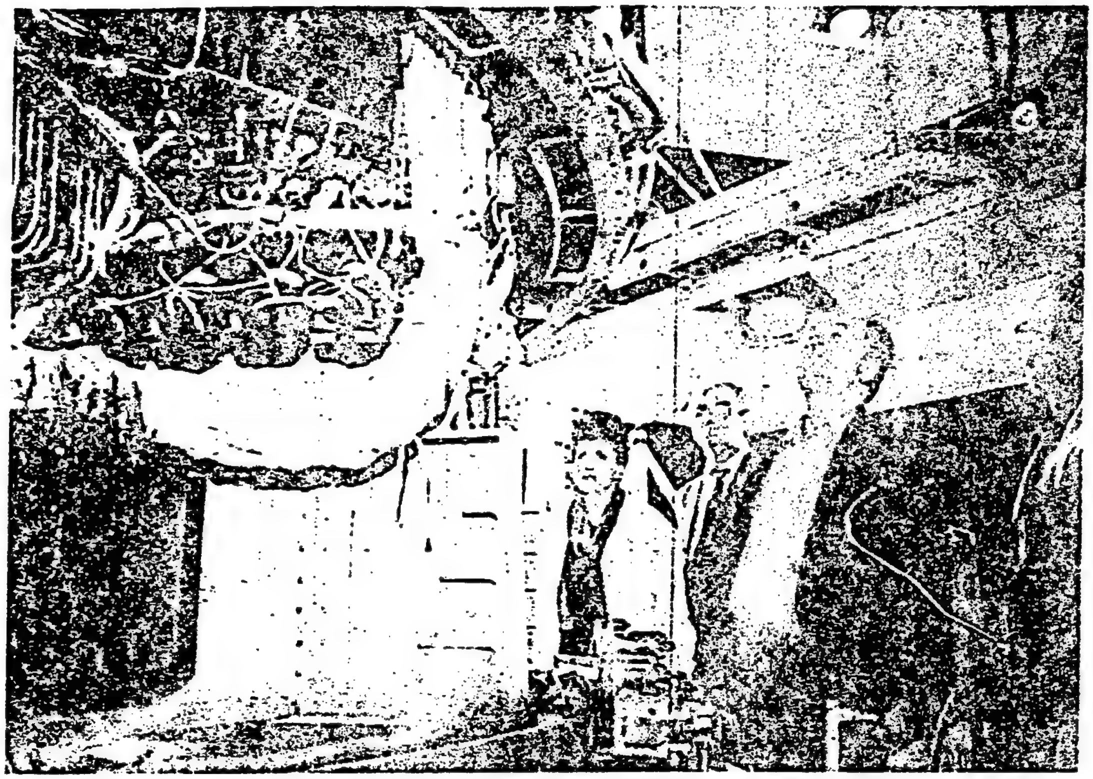
Diagram of Gamma telescope.
The mass of the telescope is about 1,500 kg.

Key: 1. Satellite skin—2. Anticoincidence scintillation counters—3. 12-Gap spark chamber—4. Upper scintillator—5. Gas Cerenkov counter—6. Lower scintillator—7. 2-Gap spark chamber—8. Scintillation calorimeter—9. Mask—10. Mirror system—11. Television camera

Work in Orbit

The actual operation of the orbservatory in orbit has demonstrated the reliability of the onboard service systems and the good controllability of the observatory's attitude. In the performance of dynamic maneuvers, fuel consumption has proved to be considerable lower than what was expected, which will make it possible, if need be, to extend the time of flight.

There have been two malfunctions in the science instrument package, however. The Disk-M telescope stopped working, and the there is no power to trigger the spark chambers of Gamma-1. As a result, the angular resolution



A scene from the preparation of the observatory at Baykonur.

of Gamma-1 is 10°. The other systems of Gamma-1 are working well. Thanks to the telescope's high sensitivity and to the high temporal resolution, a great deal of new information has been gathered in the field of high-energy gamma astronomy. Primary attention in that experiment is being focused on searching out and studying sources of variable gamma radiation. At the same time, the Earth's radiation belts at low altitudes (in the Brazil anomaly) are being studied, as is the electron component of cosmic rays. High-energy gamma radiation from the Sun is being studied at peak solar activity. Studies have been made of the pulsar in the Vela constellation, the center of the Galaxy, the binary system in the Cygnus constellation, the Heming gamma source (constellation Taurus), and the binary system in the constellation Hercules. The information is being processed in science centers in the USSR Academy of Sciences and in France.

The next issue of ZEMLYA I VSELENNAYA will carry an article about specific results of the research that has been performed.

It must be said that the creation of the Gamma-1 observatory not only opens up new possibilities in the study of the Universe, but also enables the planning of a broad program of observatory use for the purpose of solving problems of the national economy. In particular, the creation of an ecological module based on the Gamma observatory is envisaged for space-based monitoring of the Earth's atmosphere, the world ocean, landlocked water bodies, forests, and crops and for forecasting and observing natural disasters. The structure and composition of the service systems of the ecological module would be virtually the same, except, of course, that other instrumentation would replace the telescopes studying gamma radiation.

The life of the new observatory is just beginning. It is expected to serve people long and well.

USSR: 'Granat' Satellite Mission Continuing

927Q0034A Moscow PRAVDA in Russian 5 Dec 91 p 3

[Interview with Ye. Vazhnova, leader of an analysis group at the Scientific Research Center imeni G.N. Babakin, by Yu. Markov; place and date not given: " 'Granat', Scorpio, and Cygnus]

[Text] Analysis group leader Ye. Vazhnova, an employee of the Scientific Research Center imeni G.N. Babakin, which is part of the NPO [Scientific Production Association] imeni S.A. Lavochkin, brought a report from the long-range space communications center about a "shakeup" of the "Granat" satellite in orbit.

[Markov] This astrophysical observatory has been operating in near-earth orbit for two years...

[Vazhnova] Yes, and in July of last year, the period of work of "Granat"—eight months—which was determined by the technical task, was concluded. But the exploration of outer space sources proved so successful that they were continued at the unanimous request of scientists of the USSR, France, Bulgaria, and Denmark— the project participants.

[Markov] But what are the main results that were achieved by the gamma-Roentgen astronomical scientific telescope ("Granat" is the acronym for this term)?

[Vazhnova] We will look through the reports of the Institute of Space Exploration together. The X-ray telescope "Sigma" discovered rigorous radiation from the source 1E,740.7-2942, located in a "black hole" system—and this is acknowledged by astrophysicists of the whole world to be an outstanding contribution in the exploration of the center of the Galaxy; telescope ART-11 discovered eight X-ray sources, called by the name of the space apparatus "Granat," and it discovered a sharp deceleration in the rotation of one of the pulsars; the instrument VOTCh [acronym not identified] discovered a brilliant source that flared up on 7 February 1990; unique observations were made of sources of Scorpio, Hercules, Cygnus, etc. Immediate results of the scientific explorations were reported at a forum of COSPAR [Committee on Space Research] in the Netherlands and other international scientific conferences.

[Markov] And keep in mind the report in the press that on 9 January 1991 "Granat" discovered the most brilliant heretofore unknown source in the constellation Musca?

[Vazhnova] Yes, exploration of this X-ray source continued jointly with the satellites "Ginga" (Japan) and "Rosat" (Germany), but also by observatories in Australia and Chile.

[Markov] Tell me, Yelena Ivanovna, were there any critical moments in controlling the apparatus?

[Vazhnova] But there is no way to be without them! On 22 May of last year, the first processor of the computer for the French "Sigma" telescope "got stuck." The conference lasted nine hours. The picture that developed with this telescope was very intricate. Until the situation was analyzed in direct communications with specialists who were located in France, and until "Sigma" was turned off... After this, they operated for a year on the second processor, and now, again on the first: During this time, it apparently had a good rest.

[Markov] But what effect did the solar flares have? Being the most powerful in recent years, even more threatening than during the flight of the Phobos's, they somehow affected the functioning of "Granat?"

[Vazhnova] Whether it was the solar flares, charges of static electricity, or other events—this still has yet to be determined through long and detailed analysis. But, actually, on 4 July, a drastic situation developed on board the apparatus: Unsanctioned commands were passed to turn on the onboard TsVM [digital computer] control system and to switch to another solar instrument. This occurred during normal operations when there were no radio communications, in accordance with the program. But the switch to the alternate solar recorder did not prove to be terrible: It remained in line with the one that was operating, and it immediately "locked onto" the Sun, and, therefore, no disruption in orientation occurred. But, then, the control system that was turned on almost ran down the onboard battery. When the conference was started, they quite quickly realized what had happened. They turned it off immediately and gave the apparatus an opportunity to charge itself fully with electrical energy.

[Markov] Did this become known to the foreign partners?

[Vazhnova] Of course. First, because the foreign specialists continuously participate in flight control. But, second, we regularly transmit detailed information on the state of onboard systems to our colleagues.

[Markov] What are your near-term plans?

[Vazhnova] Very soon I am once again going to the Long-Range Space Communications Center. We are like watch officers...

[Markov] And is work like this not difficult for you, a woman?

[Vazhnova] It is normal. By the way, the leader of the control group is also a woman—Nina Georgiyevna Kuleshova. When the American, Italian, and other foreign specialists visited the center, they were quite surprised by the abundance of women in flight control.

[Markov] And how much longer will "Granat" function?

[Vazhnova] I suppose, about 10 months, if nothing extraordinary happens. And, perhaps, even longer. There is still enough fuel on board for a while.

'Intercosmos 25' Satellite Launched

LD1812144691 Moscow TASS International Service in Russian 1345 GMT 18 Dec 91

[Text] Moscow, 18 Dec (TASS)—Flight Control Center reported today:

"In accordance with the international Intercosmos program of cooperation in the area of basic space research, the Tsiklon rocket launcher launched the "Intercosmos 25" artificial earth satellite in the Soviet Union from Plesetsk cosmodrome in the Soviet Union on 18 December.

The satellite's launch was prepared within the framework of the international Apeks scientific program, whose basic aim is comprehensive research into the effects of artificial influence by modulated streams of electrons and beams of plasma on the Earth's ionosphere and magnetosphere.

The "Intercosmos 25" artificial earth satellite is carrying a Czechoslovak "Magion 3" satellite. The satellites' scientific and telemetric apparatus was developed and prepared by scientists and specialists from the Republic of Bulgaria, the Hungarian Republic, the Republic of Poland, Romania, the Soviet Union, the Czechoslovak Federal Republic and the Federal Republic of Germany.

The basic scientific program will get underway after the Czechoslovak satellite has separated from "Intercosmos 25."

The satellite has been placed in orbit with the following parameters:

- maximum distance from the Earth's surface (apogee)—3083 km;

- minimum distance from the Earth's surface (perigee)—440 km;

- initial period of revolution—121.7 minutes;

- inclination of orbit—82.5 degrees.

Foreign scientists and development specialists in scientific and telemetric apparatus were involved along with Soviet specialists in tests and in preparing for the launch of the satellites at the cosmodrome.

The on-board systems on the "Intercosmos-25" satellite are working normally.

Ground stations at a control center in the Soviet Union and a telemetric information receiving station in the CSFR are receiving incoming information from the satellite.

'Magion-3' Subsatellite Deployed

LD2912225691 Moscow TASS in English 1750 GMT 29 Dec 91

[Text] Moscow December 29 TASS—On December 28 1991, the Czechoslovak satellite "Magion-3" was separated from "Interkosmos-25" artificial earth satellite launched on December 18, 1991. "Magion-3" satellite carries equipment made in Bulgaria, Hungary, Poland, Romania, the Soviet Union, Czechoslovakia and Germany. "Magion-3" satellite has a "Pursar" engine for multiple corrections of its orbit in accordance with the flight program.

The implementation of a comprehensive scientific programme with the use of two spacecraft and a network of geophysical observatories in various countries begins after "Magion-3" satellite separates. Interaction of electron currents with beams of plasma and the earth's ionosphere and magnetosphere will be studied by means of equipment on board the satellite. There will also be observations from the ground.

The parameters of "Magion-3" satellite are similar to those of "Interkosmos-25".

Onboard systems and scientific equipment is functioning normally. The incoming information is being processed.

Scientists Begin 'Apex' Space Project

LD0101181392 Moscow TASS International Service in Russian 1900 GMT 28 Dec 91

[By TASS observer Vladimir Khrustov]

[Text] Moscow, 28 Dec (TASS)—Scientists and specialists of the Intercosmos program member countries have begun implementing the Apex (Active Plasma Experiments) international scientific project. A subsatellite, Magion-3, was separated today from the main satellite, Intersputnik-25, which was launched on 18 December.

Professor Viktor Orayevskiy, director of the Russian Academy's Institute of Earth Magnetism, the Ionosphere, and Radiowave Propagation, told the TASS observer in an interview that the Apex project is a new generation project to use beams of electrons and ions to investigate the mechanism of links between the sun and earth, as well as ionospheric and magnetospheric processes.

There are provisions for carrying out experiments to investigate the antenna properties of beams of electrons and ions (this being dependent on the position of the satellite in near-earth space), and also the electrodynamic characteristics of near-earth space. The use of beams of charged particles as antennas gives enormous advantages: they are structure-free antennas and do not require the deployment of metal structures in space.

It is important to note that the research into near-earth space by means of electrons and ions carried out earlier from orbiting space systems, in particular the shuttle, covered a fairly narrow area: up to 400 km in altitude and approximately plus or minus 50 degrees from the equator. In the Apex experiment the boundaries of the area being investigated are much wider: 3,000 km at the pole and about 50,000 km at the equator.

The equipment on the spacecraft was created by scientists and specialists of Russia and Ukraine, as well as Czechoslovakia, Bulgaria, Poland, Germany, Hungary, and Romania.

Planar Resonant Motions and Regular Precessions of a Spacecraft With Deformable Elements

927Q0020A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 328-339

[Article by A. P. Markeyev and O. V. Kholostova]

UDC 629.19.01

[Abstract] The motion of a large deformable-element spacecraft in a central Newtonian gravitational field is

examined in the context of the usual assumption that the motion of the center of mass is independent of the rotational motion of the vehicle relative to the center of mass. A viscoelastic body serves as the mechanical model, and the elastic oscillations are assumed to take place along one of the body axes. Dissipative forces are described with a Rayleigh function. In the first part of the paper, the researchers study the planar resonant motions of a body nearly dynamically symmetrical in an elliptical orbit of arbitrary eccentricity. The spacecraft is assumed to move in such a manner that axis Ox_2 is always perpendicular to the plane of the orbit. In the second half, they examine the existence and stability of regular precessions of a dynamically symmetrical body in a circular orbit. Figures 1, references 9: 8 Russian, 1 Western.

Optimal Control of Terminal Reorientation of a Spacecraft on the Basis of An Algorithm With a Predictive Model

927Q0020B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 340-351

[Article by N. Ye. Zubov]

UDC 629

[Abstract] Terminal reorientation of a spacecraft is defined as changing the attitude of the craft in an inertial coordinate system over a given period of time from some initial position to the required ending position. In that context, researchers today are studying the optimization of terminal control that, in a fixed control time t_k, integrates the right-hand body-axes system with a program basis whose position in given in inertial space. The researchers here approach the problem of optimal control from the standpoint of analytical design based on an algorithm with a model whose form enables analytical prediction of "free" motions. A problem of terminal reorientation is solved for forms of kinematic equations in two forms of rotational motion around the center of mass—direction cosines and quaternions. Control of the angular position of the spacecraft is effected with three or more pairs of engines that create moments relative to the main axes of inertia. The researchers compare algorithm performance on the basis of two criteria; computer capacity needed to effect the algoritm, and precision of reorientation. Figures 4, references 12 (Russian).

Optimization of a Two-Impulse Rendezvous Maneuver for Two Spacecraft in a Circular Orbit With Constraints

927Q0020C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 352-366

[Article by V. V. Ivashkin and G. G. Raykunov]

UDC 629.197.2

[Abstract] The impetus behind the study of this optimization problem lies in the growing phenomenon of multisatellite systems in what are essentially circular orbits, e.g., geostationary satellites and space stations. Such systems, as the experience with the Salyut and Mir stations has shown, must be serviced by maneuverable craft that, in the future, will travel from one facility to the other in performance of their jobs. The problem here centers on a "soft" rendezvous (defined as a matching of coordinates and velocities) between an active spacecraft and a passive spacecraft traveling in the same circular orbit in the central Newtonian gravitational field of a planet. The constraints of the problem involve the time allowed to perform the maneuver and the distance from the spacecraft to the gravitational center. Figures 5, references 8 (Russian).

Minimum-Time Impulse Transfers Between Circular Coplanar Orbits

927Q0020D Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 367-374

[Article by S. N. Kirpichnikov, A. N. Bobkova, and Yu. V. Oskina]

UDC 531.55:521.1

[Abstract] In a study of the optimum impulse trajectories for transfers between circular coplanar orbits in a central Newtonian gravity field, the duration of the interorbit segment of motion is minimized for a given characteristic maneuver velocity. The direction of motion in contiguous orbits can be either the same or the opposite, but the researchers take a technique developed by S. N. Kirpichnikov for formulating a problem involving same-direction motion and apply it to contiguous orbits with opposite directions of motion. They derive equations for finding the optimum parameters of two-impulse transfers, determine the type of orbits needed for such transfers, and prove the local optimality in multiimpulse, minimum-time transfers between similar contiguous orbits with the same characteristic maneuver velocity. Figures 3, references 11: 6 Russian, 5 Western.

Improving the Accuracy in the Determination of the Rotational Motion of the Salyut-6 and Salyut-7 Orbital Stations From Measurement Data

927Q0020 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 375-389

[Article by V. A. Sarychev, V. V. Sazonov, M. Yu. Belyayev, and N. I. Yefimov]

UDC 629.7

[Abstract] A continuation of an article that described a technique for determining the rotational motion of the Salyut-6 and -7 orbital facilities from the data of onboard measurements made by solar and magnetic sensors (V. A. Sarychev *et al.*, KOSMICH. ISSLED., 1988, Vol 26, No 3, p 390), this paper explores various methods for improving the accuracy of that technique. The improved technique involves a threefold process: eliminating a constant error component from the magnetic sensor readings, increasing the number of parameters considered in the processing of the onboard data, and including stellar photometer readings in the measurements that are used to determine the motion. The researchers first describe a mathematical model that considers the displacement of the station's main central axes of inertia from the axes of the structural system of coordinates. Then formulas are introduced for calculating the coefficients and right sides of normal equations of the least squares method, with the results of actual measurement information processed with the modified technique compared with the results of the use of the old technique. The final part of the article contains an analysis of the results of the processing of stellar photometer readings. Error in determining station attitude moves from a figure that is less than or approximately equal to 2° (with the old technique, without the photometer readings) to a figure that is less than or approximately equal to 1° (with the photometer readings). Figures 5, references 3 (Russian).

Study of Orbits With Multiple Passes of Earth and Mars

927Q0020F Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 390-396

[Article by A. V. Labunskiy]

UDC 629.015

[Abstract] After a two-decade hiatus, multiple-trajectory flights of spacecraft between Earth and Mars are again the focus of attention in connection with the preparations for a manned flight to Mars. One stage of those preparations could very well involve long-duration, multiple-pass missions of unmanned vehicles that would study near-planet regions and the physical processes that take place in the solar system and could be used as navigational systems for later manned flights. Designing interplanetary orbits that make multiple passes of planets is complicated by the fact that such orbits would have to take advantage of the gravitational fields of the Sun and the planets and would have to satisfy requirements and constraints involving power consumption, geometry, and time. Small changes in the positions of the Earth and Mars relative to each other can markedly influence the spacecraft's orbit, as can the perturbation effect. Only a numerical study of such profiles on comprehensive mathematical models can identify the optimal profile characteristics, to include launch window, flight calendar, flyby dates, trajectory characteristics, and power-consumption requirements. The researcher studies numerical solutions in the context of an all-purpose algorithm for the design of multipurpose spacecraft orbits. The results are analyzed for multipass flights with launch dates between 1992 and 2012. Figures 4, references 3 (Russian).

Optimal Shapes of Thin Bodies With Minimal Aerodynamic Heating During Motion in the Atmospheres of Solar System Planets

927Q0020G Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 397-403

[Article by M. A. Korchagina, N. N. Pilyugin]

UDC 535.8

[Abstract] An earlier paper focusing on choice of shapes with minimal aerodynamic heating (KOSMICH. ISSLED., 1991, Vol 29, No 2, p 298) produced numerical solutions for variation problems involving minimal total convective and radiational thermal fluxes at the surfaces of axisymmetric and flat bodies traveling at supersonic speeds in a planetary atmosphere. This paper presents the results of those solutions for various isoperimeter and boundary conditions for various kinds of entry into the planetary atmosphere. The contours for the optimum bodies are compared, and the coefficients of radiant and convective heating are computed. Shock-wave drag and friction resistance are also determined. The calculations are performed for the giant planets, as well as for the Earth group. Optimization is achieved primarily through radiant heating, owing to the fact that the functional of radiant heating changes considerably with only small changes in shape, especially for high-speed entries into an atmosphere. The functional for convective thermal exchange, however, changes little, even when shape undergoes substantial modification. With given values for middle radius and volume, the total heating of an axisymmetric body with optimal shape is 38 percent less than with a wedge shape; for a optimal flat body, it is 27 percent than with a wedge. Figures 5, references 4.

Comparative Analysis of Various Hydrodynamic Approximations For Describing Ionospheric-Magnetospheric Plasma

927Q0020H Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 404-413

[Article by M. N. Vlasov, S. A. Grigoryev, S. A. Ishanov, and K. S. Latyshev]

UDC 551.510.53

[Abstract] Diffusional approximation and total hydrodynamic description are compared on the basis of a number solution of a system of equations of continuity, motion,

and energy for O^+ and H^+ ions and electrons along the midlatitude tube of force of the electromagnetic field (L = 3), with a low level of solar activity ($F_{10.7}$ = 70). During daylight hours, the results obtained in diffusional approximation for a two-ion problem are in good agreement with those obtained in hydrodynamic approximation. At sunset and during the night, however, the electron concentrations of the two approximations differ by a factor of 1.5-2, a fact that points to the limited applicability of ionospheric models based on diffusional approximation. The large discrepancy is explained by the fact that the night-ionosphere charged-particle fluxes Φ from the plasmasphere, as calculated in the hydrodynamic description, are considerably higher than those calculated in diffusional approximation. The differences in the distribution of O^+ in the outer ionosphere and the plasmasphere are even greater. Diffusional approximation leads to a dramatic overestimation of O^+ concentration at high altitudes. Differences are also observed in H^+ distribution along the tube of force, with the spread in altitude profiles in the plasmasphere almost identical for the entire 24 hours. Hydrodynamic description also shows a higher concentration of charged particles, whereas electron and ion temperatures are virtually identical. In the hydrodynamic approximation, the altitude of transition (where $[O^+]/[H^+] \approx 1$) is lower at night. The principal conclusion of the paper is that in quiet geomagnetic conditions, the fluxes that underlie the intermingling of ionosphere and plasmasphere are hydrodynamic, and not diffusional. Figures 6, references 12: 7 Russian, 5 Western.

Radial and Pitch-Angle Diffusion of Electrons of the Earth's Radiation Belt, As Reconstructed From Intercosmos-19 Data

927Q0020I Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 414-421

[Article by Yu. V. Mineyev, P. I. Shavrin, and I. B. Volkov]

UDC 551.521.8

[Abstract] Intercosmos-19 data for measurements of the energy spectra and pitch-angle distribution of electrons with energies of 0.3-2 MeV are used to calculate the electron distribution function in the inner radiation belt. Equations of radial diffusion yield diffusion coefficients D_{LL} for both the inner belt L = 1.2-1.4) and the outer belt (L = 3-5.5). For the inner radiation belt, solution of an equation of diffusion produced a D_{LL} value of approximately 10^{-5} day^{-1} at L = 1.2-1.4 and a D_0 value of approximately 3 x 10^{-6} $R_3{}^2$/day for electrons with energies E_e of about 1 MeV. For the outer belt, observed diffusion wave parameters were used to produce values of $D_{LL} \simeq 10^{-4}$-10^{-1} day^{-1} for L = 3-4.5. Pitch-angle diffusion coefficient $D_{\alpha\alpha}$ values were determined to be approximately 10^{-1} day^{-1} for E_e = 1 MeV, L = 3.5 from data on both electron flux "decay" and wave emissions. Figures 6, references 14: 10 Russian, 4 Western.

Properties of Electrostatic Turbulence and Observations of Non-Maxwellian Distributions of Charged Particle Fluxes in the Low-Latitude Magnetosphere

927Q0020J Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 422-426

[Article by N. M. Shyutte and N. I. Izhovkina]

UDC 533.951

[Abstract] Patterns observed partly in Cosmos-900 data in the detection of nonMaxwellian distributions of fluxes of charged particles with energies of 100 eV or more in the low-latitude upper ionosphere served as the starting point for the research reported here. To wit, nonMaxwellian distributions are associated with intense fluxes of charged particles in the low-latitude magnetosphere (L, 2) at ionospheric altitudes (h, 500 km), bursts of charged particles in regions with elevated internal-geomagnetic-field heterogeneity are observed in 90 percent of all measurements, and the particle energy distribution for those intense bursts has spikes in the high-energy tail of the distribution function. This paper demonstrates that threshold mechanisms—threshold in terms of background plasma density—for the oscillation of electrostatic turbulence resulting from the development of loss cone instability in the low-latitude magnetosphere can be used to explain the experimental finding that nonMaxwellian energy distributions with such spikes are observed for intense bursts of charged particles only. Figures 3, references 7: 3 Russian, 4 Western.

Turbulent Processes of Pickup of New Ions Near Venus and Mars and Problems of Numerical Models of Interaction Between Solar Wind and Those Planets. I. Two-Fluid MHD Model

927Q0020K Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 432-442

[Article by T. K. Breus, A. M. Krymskiy, V. Ya. Mitnitskiy]

UDC 523.72:523.43

[Abstract] In part II of a paper, a two-fluid MHD model is proposed for the interaction between solar wind and Venus and Mars, with anomalous friction between protons and ions of oxygen. Part I (KOSMICH. ISSLED., 1990, Vol 28, No 6, p 923) demonstrated that the anomalous friction between ion species near Venus is due to turbulent processes in the magnetosheath. Fobos-2 measurements showed that the level of turbulence throughout the magnetosheath near Mars is also high, leading one to believe that turbulent processes of acceleration of heavy ions also play a key role near Mars. The researchers here compare the results of calculations for Venus and Mars with Pioneer Venus data and with data

produced earlier in the context of a one-fluid model, as well as with preliminary findings based on O^+ measurements made from elliptical orbits by Fobos-2 on the dayside of the Martial magnetosheath. The researchers' model is an atmosphere consisting of a mixture of hydrogen and atomic oxygen, with only protons and ions of O^+ in the plasma. That enables examination of mass-loading near Venus. The model assumes that each species of ion can be described with its own equation of continuity. The velocity of both species is assumed to be identical, such that the motion of the plasma ions can be described by a single equation of motion. One energy balance equation is also assumed to hold true. A more detailed comparison will be possible after calculations of the flow around the planets are made in a model of a neutral atmosphere that corresponds to a solar activity maximum and after refinements are made in the shape and position of obstacle near Mars and in the characteristics of the solar wind flow around Mars based on Fobos-2 data. Figures 5, references 15: 3 Russian, 12 Western.

Inverse Problem of in situ Photometry of Scattered Solar Radiation in a Planetary Atmosphere: Reconstruction of Atmospheric Scattering Characteristics. Mathematics and Numerical Experimenta.

927Q0020L Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 443-457

[Article by Ye. A. Ustinov]

UDC 535.24:523.42

[Abstract] Atmospheric aerosol can be used as a tracer of various processes in a planetary atmosphere. In situ photometry of scattered solar radiation is one of the most effective methods of studying such an aerosol in that it is less sensitive to local fluctuations than is nephelometry. The traditional method of interpreting photometry observations of solar radiation scattered by a planetary atmosphere is to solve a direct problem of radiative transfer for a set of optical models of atmospheres, with subsequent selection of the model that best reproduces the measurement results. But the search for the appropriate model can, to some extent, amount to guesswork, which is why the researcher here chose to set up an inverse problem of radiative transfer. The purpose of the work reported here was to generalize the results of earlier work involving multiple scattering (KOSMICH. ISSLED., 1977, Vol 15, No 5, pp 768-775; "Direct and Inverse Problems of the Theory of Multiple Scattering and Their Use in the Interpretation of Photometric Measurements Made From Descent Stages of Venera-9 and Venera-10": Dissertation, Moscow, Space Research Institute, 1978). In the process, the researcher performed munerical experiments in the reconstruction of scattering characteristics for conservative and nonconservative models of planetary atmospheres. To offset the essential incorrectness of the inverse problem (which includes numerical differentiation of measurement results by altitude), the researcher applied statistical regularization. Vertical profiles were obtained for the parameters of atmospheric scattering that determine the transfer of scattered solar radiation in an optically thick atmosphere where the contribution of direct solar radiation to the source function is negligible. The numerical experiments that were performed demonstrated that in a conservative scattering atmosphere, only a vertical profile of the atmospheric parameter that determines radiation intensity field, χ_1 ($\chi_0 = 0$), can be produced from the results of in situ photometry. If there is absorption in the atmosphere, then, in addition to χ_0 and χ_1, profiles for the parameters χ_l ($l \geq 2$) can be reconstructed. Paired ratios of the parameters $\chi_l^{(a)}/\chi_k^{(a)}$ for the aerosol can be determined only by its microphysical characteristics. Figures 8, references 18: 15 Russian, 3 Western.

Distribution of Electron Concentration in Halley's Comet: Solution of Inverse Problem On the Basis of Radio Occultation Data

927Q0020M Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 458-467

[Article by V. Ye. Andreyev and A. L. Gavrik]

UDC 523.6

[Abstract] In the rendezvous with Halley's Comet, Vega-1 and Vega-2 sounded the comet with radio-transmitting devices that emitted coherent signals, one in the decimeter range ($\lambda_1 = 32$ cm) and the other in the centimeter range ($\lambda_2 = 5$ cm). The work reported here involves the solution of an inverse problem for two-frequency radio probing of the comet's plasma envelope, i.e., to produce profiles of electron concentration $N(h)$ in the comet on the basis of Vega-1 and Vega-2 radiophysical data. The researchers found that the highest electron concentration in both cases is achieved at a cometocentric distance of about 11.5×10^3 km (3.6×10^3 cm^{-3} on 6 Mar 86, and 1.9×10^3 cm^{-3} on 9 Mar 86). Figures 5, references 15: 10 Russian, 5 Western.

Experimental Studies of Electrical Conductivity of Outer Atmosphere of Spacecraft on 'Cosmos' Satellites

927Q0020N Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 29, No 3, May-Jun 91 pp 468-477

[Article by V. A. Kochnev, A. K. Kuts, V. V. Kanyushkin, E. D. Molchanov, D. D. Milyutin, and Yu. G. Pekhterev]

UDC 581.521

[Abstract] Results of the measurement of leakage currents from potential elements to the atmosphere outside

the Cosmos-1514 and Cosmos-1667 spacecraft are presented. The experiments represent the first full-scale studies of the mechanism underlying the interaction of potential elements and the outside atmosphere of a spacecraft in near-Earth orbit at working voltages of up to 10 kV. They demonstrated that the leakage current density was no more than 3×10^{-1} A/m^2 at voltages of up to +10 kV and no more than 6×10^{-2} A/m^2 at voltages down to -10 kV. The density of the leakage currents from the potential elements to the spacecraft body was two-three times less than the density of the leakage current from potential elements to the atmosphere outside the spacecraft. Currents from a positive potential surface exceeded currents from a negative surface by a factor of 2. Figures 4, references 7 (Russian).

Observation of Pulsar PSR 0833-45 With the Gamma-1 Telescope

927Q0016A Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 17 No 6, Jun 91 (manuscript received 18 Feb 91) pp 501-504

[Article by V. V. Akimov, V. G. Afanasyev, V. M. Balebanov, I. D. Blokhintsev, M. M. Boyarskiy, V. A. Volzhenskaya, Ye. A. Gavrilova, L. F. Kalinkin, I. M. Kizenkov, V. D. Kozlov, N. G. Leykov, G. A. Mersov, V. Ye. Nesterov, N. V. Plyusnina, V. L. Prokhin, S. V. Repin, V. G. Rodin, A. A. Sukhanov, A. A. Tikhonov, V. N. Chuprov, Space Research Institute, USSR Academy of Sciences, Moscow; A. S. Belousov, D. A. Burgeyev, M. B. Dobriyan, R. I. Kanuper, B. T. Karimov, T. I. Kirillova, Ye. A. Kornev, A. Ch. Kurmangaliyev, N. K. Mordvov, L. G. Mosevnina, S. R. Tabaldyyev, D. G. Shevchenko, V. S. Shmelev, S. I. Yampolskiy, Special Design Office, Space Research Institute, USSR Academy of Sciences, Moscow; S. A. Boronov, A. M. Galper, V. A. Grigoryev, V. G. Zverev, V. M. Zemskov, V. G. Kirillov-Ugryumov, M. G. Korotkov, B. I. Luchkov, A. A. Moiseyev, Yu. B. Ozerov, A. V. Popov, V. A. Rudko, M. F. Runtso, V. Yu. Chesnokov, Yu. T. Yurkin, Moscow Engineering Physics Institute; V. L. Ginzburg, L. V. Kurnosova, L. A. Razorenov, M. A. Rusakovich, N. P. Topchiyev, M. I. Fradkin, Physics Institute, USSR Academy of Sciences, Moscow; I. F. Bugakov, Ye. I. Chyukin, Physical Technical Institute, Leningrad; I. A. Gerasimov, P. N. Polezhayev, V. P. Poluektov, A. V. Serov, V. Yu. Tugayenko, T. N. Tyan, Energiya Scientific Production Association, Kaliningrad; E. Barouch, I. Grenier, M. Gros, J. Ducros, J. P. Leray, B. Parlier, A. Raviart, F. Soroka, Center for Nuclear Research, Sacle, France; A. R. Bazer-Bachi, J. M. Lavigne, J. F. Olive, Center for Cosmic Radiation Research, Toulouse, France; J. Durand, J. C. Kosik, Center for Space Research, Toulouse, France; A. Buchkowska, I. Grigorchuk, K. Kossatsky, S. Makal, G. Czajkowski, R. Jozwicki, and J. Juscniewicz, Center for Space Research, Polish Academy of Sciences, and Warsaw Polytechnic Insitute, Poland]

UDC 510.6;524.354.4

[Abstract] Preliminary results are presented from August-October 1990 Gamma astrophysical satellite observation (about 300 hours) of pulsed gamma radiation from Pulsar PSR 0833-45. The pulsar is the brightest source of gamma quanta in the 10^7-10^9 eV range. The period is approximately 89 ms in the radio, optic, and gamma ranges. There is one sharp peak in the phase curve in the radio range and two peaks in the optical and gamma ranges, the latter two peaks being in substantially different locations on the curve. Interpulse radiation (radiation between peaks) is observed, but it decays exponentially after the second peak. The gamma radiation exhibits temporal variability. The shape of the light curve which was obtained is consistent with the data of the COS-B group. Pulsed gamma flux with energies $>$ 50 MeV was $(1.6 \div 2) \times 10^{-5}$ cm^{-2} s^{-1}. A power supply problem kept the researchers from turning on the spark chambers in the telescope, thereby precluding the possibility of determining the direction of each photon and the selection of gamma events from the maps in the spark chambers. The telescope, however, can be used as a wide-aperture gamma spectrometer with a total viewing angle of about 10° to 30°. Event selection criteria were chosen to provide the best signal-to-noise ratio. The shape of the phase curve which is presented is consistent with COS-B observations in terms of width and relative pulse amplitudes. Figures 2; references 3 (Western).

Aerosol in the Atmosphere of Mars From KRFM Experiment Data

927Q0016B Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 17 No 6, Jun 91 pp 548-559

[Article by V. I. Moroz, Ye. V. Petrova, L. V. Ksanformaliti, L. Esposito, J.-P. Bibring, M. Combes, A. Soufflot, O. F. Ganprantserova, N. V. Goroshkova, A. V. Zharkov, G. Ye. Nikitin, Space Research Institute, USSR Academy of Sciences, Moscow]

UDC 520.6;523.43

[Abstract] The KRFM instrument (a radiometer-photometer complex to study Mars) on the Fobos-2 spacecraft consisted of an infrared radiometer with several filters and a prism spectrophotometer for the 315-600 nm range. The spectral resolution is $\lambda/\Delta\lambda$ = 10. Photometric profiles of Mars were obtained in eight narrow spectral bands in this range. The width of beam pattern of the photometer was about 0.005 rad, corresponding to about 30 km on the surface. Limb-to-limb coverage of the equatorial region was provided. Some features in the profiles can only be explained by atmospheric aerosol. Two types of aerosol were identified: (1) constant haze (mineral dust), and (2) high-altitude clouds which may be of water ice. Brightening at the morning limb and above Arsia Mons and Pavonis Mons are examined. Using the Mie theory for spherical particles, the imaginary part of the index of refraction κ for

constant haze distribution is determined. The figures are several times higher than those found for terrestrial materials. This may be due to the irregular shape of the particles and/or the presence of an absorbing agent. Particles tenths of a micron in diameter with a real index of refraction of 1.55 fit the constant haze model. The near equatorial photometric profile at 550 nm may be explained by a weakly absorbing atmosphere. Ice particles of about the same size as haze particles may explain the bright spots over Arsia Mons and Pavonis Mons. The optical depth of ice clouds was estimated to be 0.1 with a column mass density of 7 x 10^{-5} g/cm^{-2}. Figures 5; references 27: 11 Russian, 16 Western.

Estimate of the Chemical Composition of the Dust Component of Halley's Comet

927Q0017A Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 17 No 7, Jul 91 pp 637-644

[Article by L. M. Mukhin, G. G. Dolnikov, Ye. N. Yevlanov, O. F. Prilutskiy, M. N. Fomenkova, Space Research Institute, USSR Academy of Sciences, Moscow]

UDC 523.64

[Abstract] A fundamental flaw in the interpretation of the dust-particle data obtained by Vega-1, Vega-2, and Giotto during their flybys the core of Halley's Comet consists in the fact that the spectra of the PUMA-1, PUMA-2, and PIA instruments contain only ion abundances of chemical elements, and a way needs to be found to convert from ionic to elemental composition. Although Kissel and Krueger's approach of using adjusted data for particles with velocities considerably lower than the actual velocities, plus relative ion yields, provides good results, it has a weak spot in that it considers dust-particle mass to be proportional to the total number of ions in the spectrum. A new approach is used here to determine the dust-particle composition of Halley's Comet. The mass of the particles is estimated from four signals measured when a dust particle hits the target. It is shown that when weight factors are used, the average ion composition of cometary dust is close to solar composition. The average ion abundances of the main rock-forming elements in particles of different mass or composition are compared, as are the abundances of the rock-forming fraction of organic (C, H, O, N) and mineral particles. The average ion abundances of the main chemical elements are estimated over the entire spectrum, based on the mass of the dust particles. Figures 3; references 13: 4 Russian 9 Western.

6-Meter Telescope Autocollimation Echelle Spectrometer

927Q0017B Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 17 No 7, Jul 91 pp 645-652

[Article by V. G. Klochkova, V. Ye. Panchuk, and V. P. Ryadchenko, Special Astrophysical Observatory, USSR Academy of Sciences, Nizhniy Arkhyz]

UDC 520.626

[Abstract] The ESPAC autocollimation Echelle spectrometer installed on the 6-m telescope at the Special Astrophysical Observatory in Nizhniy Arkhyz can be used with a two-dimensional photon counter or with a CCD matrix. Observations have shown that the spectrometer can record stars with $V = 12^m$ with a spectral resolution of 0.2 angstroms and a signal-to-noise ratio of no lower than 40. Twenty-four spectral orders can be recorded with the photon counter; 27 with the CCD matrix. The spectrometer is intended to record the spectra of objects whose luminosity substantially exceeds the luminosity of the background. Then, spectral orders can be densely packed without reserving room for the background spectrum. When a two-dimensional photon counter is used, one can change the number of spectral orders recorded simultaneously (and the length of the fragment of each order, the inverse linear dispersion). The advantages and disadvantages of this scheme are discussed and suggestions are made on how to improve the instrument. There is also a detailed discussion of the CCD matrix developed for the spectrometer. Figures 4; references 11: 5 Russian, 6 Western.

Effect of Hypothetical Trans-Neptunian Planets on the Motion of Several Solar System Bodies

927Q0018A Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 25 No 3, May-Jun 91 pp 309-311

[Article by M. V. Bazhkova, Ye. N. Makarova, Yu. D. Medvedev, Institute of Theoretical Astronomy, USSR Academy of Sciences]

UDC 521.41

[Abstract] The discovery of Pluto did not solve the problem of discrepancies in the orbits of Uranus and Neptune. A number of models have been proposed for the orbit of planet X. However, most of them fail to consider the effects a planet would have on known solar system objects. This article examines the proposals of Brady, Guliyev and Radziyevskiy on the basis of analysis of the effects from transneptunian planets on the motion of Halley's Comet, Uranus, and Neptune. Three bodies were used in the calculations: the Sun, a planet or comet, and planet X. The perturbations were determined using Encke's method. Numerical integration of the equations of motion was done using a fifteenth-order Everhardt method with automatic step selection. Tables give the results of calculations. Brady's planet fully explains discrepancies in the motion of Halley's Comet, but has too large an effect on Uranus and Neptune. Guliyev's planet explains only a small part of the discrepancies in Halley's Comet and has a rather large effect on Uranus and Neptune. Brady's and Guliyev's planets are unlikely candidates given the mass values which are assumed. Radziyevskiy's planet has virtually no effect on Halley's Comet. Its effect on Neptune and Uranus is also small, and these effects do not contradict the constraints imposed on the discrepancies in the observed positions of known bodies. References 7: 5 Russian, 2 Western.

On the Existence of a Swarm of Particles Near the Orbit of Phobos

927Q0018B Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 25 No 3, May-Jun 91 pp 317-326

[Article by A. V. Krivov, L. L. Sokolov, K. V. Kholshevnikov and V. A. Shor, Leningrad University, Institute of Theoretical Astronomy, USSR Academy of Sciences]

UDC 523.43-87:523.62

[Abstract] It is proved that there is a swarm of particles near the orbit of Phobos. The size and density of swarm material are determined, and these values exceed the interplanetary values by 5-6 orders of magnitude. When meteorites fall on Phobos, more than the mass of the object is ejected into space. This is beacause on small planets the escape velocity is considerably less than the ejection speed of particles after an impact. The meteoroids scattered in the ellipsoidal torus are gradually "bailed out" by Phobos. The particles fall back to the planet, but at low speeds, so that they are not ejected again. The ejection-bailout balance leads to an equilibrium state in less than 100 years. The lifetime of a particle in the swarm is about 50 years. Ring formation is not considered. References 15: 5 Russian, 10 Western.

Complex Modeling of the Atmospheric Flight and Explosion of a Meteor

927Q0018C Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 25 No 3, May-Jun 91 pp 327-343

[Article by V. P. Korobeynikov, P. I. Chushkin, and L. V. Shurshalov, Computer Center, USSR Academy of Sciences]

UDC 523.51

[Abstract] A complex of gas dynamic models is proposed for the study of the interaction of a meteor with the Earth's atmosphere when its flight ends in explosive decay in air. The complex uses an model of the authors and supplements it with other models. The complex includes a model of the equivalent explosion of a semi-infinite cylindrical charge, a model of radiation and heat effects, a flight model, and a model of the explosion of a flying body. Many models of the properties and explosive decay of the Tunguska object have been advanced, and some of these are discussed. The Tunguska object is used as an example, and refined estimates are obtained of its basic parameters. The proposed genetic link of the Tunguska object with Comet Encke is very probable. A good agreement is obtained between model results and the observed effects of the Tunguska event. Figures 12; references 49: 44 Russian, 5 Western.

Atmospheric Fragmentation of Meteors From the Point of View of Mechanical Strength

927Q0018D Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 25 No 3, May-Jun 91 pp 364-371

[Article by V. I. Tsvetkov and A. Ya. Skripnik, All-Union Astronomical-Geodesic Society, Moscow branch]

UDC 523.68

[Abstract] Large meteors break up in the Earth's atmosphere as a result of mechanical loads. This article considers three factors which affect the breakup of a meteor in the atmosphere: the loads on the body moving in the atmosphere; its geometry, which is responsible for the distribution of stress; and the durability of the meteor material. Inhomogeneity of the material should also be taken into consideration. The loads acting on the meteor are mass forces of inertia and aerodynamic resistance

pressure, which is distributed along the forward surface of the meteor. Irregular geometries are a difficult factor to consider. it is also pointed out that calculations usually assume single-axis pressure, which is not typically the case. The form of breakage depends on whether the material is plastic or brittle. A table shows that the durability of a meteor is not correlated to its chemical or petrological form. Compression stress is found to be greater than expansion stress and equivalent stresses are calculated for the so-called danger points of a meteor body. Stress distribution and a scale factor are also conisidered. Figures 3; references 15: 6 Russian, 9 Western.

Orbital Solar Electric Power Stations

917Q0141 Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA KOSMONAVTIKA, ASTRONOMIYA in Russian No 3, Mar 91 pp 1-38

[Annotation, Table of Contents, Introduction, Bibliography and pages 1-38 of monograph "Kosmicheskiye Solnechnyye Elektrostantsii" (Space-Based Solar Electric Power Stations) by Ye. A. Narimanov, edited by I. G. Virko, Moscow, Znaniye Publishing House, 1991, 64 pp]

[Text]

Annotation

Space-based solar power engineering is one of the power-generation alternatives of the future. The development of space-based solar electric power stations is a complex problem, and this monograph is devoted to various aspects of that. It is intended for a broad range of readers.

Table of Contents

Introduction

Energy is an eternal delight.—William Blake

Power generation is one of the basic sectors of industry. Its level of development, to a large extent, determines the progress of a country's entire economy. Modern methods of producing electric power—the most efficient type of energy—involve the burning of precious fossil fuels, and power-generating industries have an adverse impact on the environment. At the same time, the growth of production presupposes a further increase in electric-power consumption on a planet-wide scale. Therefore, the search for new, large-scale, ecologically clean sources of electric power is extremely pressing.

Along with thermonuclear power stations, the production of electricity in space and its transmission to the ground via a microwave beam must be considered a promising area in power generation of the future. The space vehicle that will utilize the energy of solar radiation, convert it to electricity, and transmit the energy from space to the ground in the form of a beam of electromagnetic waves has come to be called a space-based solar electric power station. In light of the ever expanding scope of the use of outer space for national economic purposes and the progress in individual areas of the industrialization of space, the assessment of the prospects for such stations and the prediction of their development are acquiring especial significance. It should be noted that such an assessment was conducted in the 1980s. The opinions of the leading domestic and foreign scientists on the problems of space-based solar power-generation differ in their polarity—from sharply negative to extremely optimistic. The reason for that lies, apparently, in the complexity of the matter, in the lack of needed information, and in the remoteness of the time frames for the realization of the proposed gigantic power-station projects.

An attempt has been made in this monograph to illuminate objectively all of the most acute questions which determine the design approaches and the commercial possibilities of new types of energy systems. It has been proposed that attention be focused on designs of low- and medium-capacity space-based power stations that could be built in the late 1990s or in the first decade of the new century. Such small-scale power plants could solve important national economic problems and, at the same time, support the transition to the development of higher-capacity energy systems. Complicated problems await the developers of the new equipment, and with this monograph, the reader will be able to learn about the means for solving them. If the task is accomplished, humanity will get a new source of energy, thereby ensuring the preservation of fossil-fuel energy sources on Earth for future generations.

The Space Program and the Realities of the Modern World

The last quarter of this century represents a long series of warnings.—N. N. Moiseyev

During last few decades of our century, humanity has unexpectedly encountered a set of global problems, each of which has acquired a fateful significance for the world—the danger of the nuclear self-destruction of humanity or the catastrophic radioactive contamination

of the biosphere; the need for effective protection of the environmen; reducing the adverse impact of man's activities on nature and on the Earth's climate; the difficulties in providing the Earth's population with enough fuel and energy resources and raw materials resources, as well as food products; and the need to increase the quality and span of people's lives.

Depletion of the Earth's resources, a decrease in soil fertility, an unrestrained increase in the Earth's population, a reduction in the areas occupied by tropical forests, a decrease in the atmosphere's ozone content, the pollution of the oceans, the accumulation of nuclear and chemical industrial wastes and many other things accompany the development of civilization in its current stage, and they are looking more and more like a slide into an abyss. Urgent measures are needed to overcome negative trends, to harmonize international relations, to streamline economic activities, to eliminate interethnic strife, and to facilitate the coexistence of world religions.

Until recently, it was believed that the basic conflict of our time was the conflict between two sociopolitical systems—the world of socialism and the world of capitalism. That conflict was viewed as an antagonistic conflict that did not permit compromises. The new political thinking has illuminated vividly the profound error of that approach. The main conflict must be considered to be the conflict between Nature and Man and between Nature and Society. The resolution of conflicts by forceful methods and demonstrations of force should be replaced by the search for compromises and the signing of mutually beneficial agreements.

The decline of the military confrontation between the leading nuclear powers, the USSR and the USA, and the reduction of the nuclear arsenals have pushed aside the threat of humanity's self-destruction, but have not eliminated it completely. Being pushed to the forefront are the problems of preventing an unauthorized nuclear attack, acts of international terrorism, and accidents at industrial installations which use nuclear fuel and radioactive substances—nuclear plants, nuclear fuel enrichment plants, radioactive waste storage sites, etc. After those fundamental problems have been solved, the priority problems on the agenda will inevitably be the economic and ecological ones, as well as the problems of the moral improvement of man.

In which direction is it necessary to search for approaches to these new problems? What should be the means and methods for their solution?

It is obvious that the role of an applied space program in solving these problems will be considerable. With the aid of the space program, rational solutions will be found for many problems—primarily, the problem of raw materials for energy and the ecology problem.

The space program represents a new, highly efficient sector of the national economy. Today, the basic product of this new sector's activities is information—for science and for the national economy. Communications, television broadcasting, the Earth resources study, meteorology, navigation, the rescue of people in distress—that is a far-from-complete list of the information systems the Earth's economy needs to get by.

The time is not far off when the space program's systems will support the large-scale production in space of materials with unique properties and pharmacological preparations unlike any here on the ground and will make it possible to use the energy of solar radiation in space and on Earth, mine the resources of the Moon and the asteroids, deliver the valuable mined materiald to Earth, and take the waste from harmful industrial plants into space, thereby saving the biosphere from the danger of contamination.

The whole set of production tasks in space listed above can be consolidated under the term "industrialization of space." There is no doubt that the industrialization of space as early as in the first half of the 21st century will become one of the basic spheres of humanity's practical activities. Among the individual areas of the industrialization of space, of special importance will be the exploitation of outer space's energy resources for Earth's needs.

Solar Energy for the National Economy

The direct use of solar heat and sunlight should be the object of further improvements in power-generation facilities.—P. A. Florenskiy

The level of a country's economic development, the improvement of applied technologies and the productivity of labor in the various economic sectors are determined to a large extent by the amount of energy produced and used—in particular, electrical energy. For man, energy is a unique currency that he uses to pay for his vital activities, as he satisfies his needs for food, clothing, and all the good things of civilization. Power-generation facilities represent the backbone of material culture. The manufacturing processes of all industrial plants, without exception, can be viewed as the aggregate of the individual stages of the consumption and conversion of energy. For a long time, there existed a firm connection between economic growth and the level of development of power generation: to increase the national product by 1 percent, it was necessary to effect the same increase in energy consumption. In the 1990s, the relationship between the growth of an economic system and power generation, in the opinion of experts, will be quite different. In the world's advanced countries, the increase in the consumption of primary energy resources will be somewhat less than the growth of the gross national product. That means that, despite energy-conservation policies and the conservation of fossil-fuel energy resources, their consumption will rise, and the burden on the planet's resource potential will increase.

The world as a whole remains extremely wasteful of energy. Being burned today in the boilers of heat and electric power stations, in internal combustion engines

and in heating units is precious organic fuel—the products of the refining of oil, gas and coal. And until the middle of the 21st century, hydrocarbon fuels will retain their predominant position in the fuel-energy balance. Coal's share in the world energy balance will rise, which corresponds to the ratio of the proven energy resources—the coal reserves on the planet are enormous and can support the needs of world power-generation for 200 years and more.

But there are ecological impediments in the path of uncontrolled growth of power generation—the increasing pollution of the environment and the deterioration of people's living conditions. Annually, 200 billion tons of carbon dioxide are released into the atmosphere, as a result of which its content in the atmosphere has increased appreciably and exceeds the level of the 1940s by 20 percent. Thermal pollution of the atmosphere is also occurring. According to the specialists' estimates, Earth's civilization is producing at the present time 10^{13} W of various types of energy, which dissipates in the atmosphere as a result of conversion. A value of 10^{14} W, which may be attained by the middle of the 21st century, will amount to 0.1 percent of the solar energy falling on the Earth and will lead to an increase in the Earth's average temperature of 0.1°. That represents a critical figure. It is well known that changes in the Sun's radiant emittance by that same magnitude have caused substantial changes in established weather and climatic conditions on the planet. The increase in the average temperatures of the Earth's surface and atmosphere may be associated with the greenhouse effect, caused by an increase in the content of carbon dioxide in the planet's atmospheric shell. According to some estimates, because of the strong infrared radiation absorption resulting from the greenhouse effect, the increase in the average temperature by the year 2050 may reach values of 0.5-1.0°C, which would mean a catastrophe of an apocalyptic nature.

In order to save the Earth's biosphere from the extremely negative effects of the power-generation facilities of the world's industrially developed countries, a set of measures is needed that would encompass the diverse ways and means of alternative energy supply. They may include efficient energy-conservation policies, the use of renewable energy sources (the energy of the Sun, the wind, and the tides and geothermal energy), the commissioning of thermonuclear power stations and a change in people's lives consisting of sensible self-restraint in the consumption of resources.

All those new means of supplying energy are being studied carefully at the present time by engineers and scientists, intensive research is being carried out, full-scale experiments are being conducted, and experimental and demonstration installations are being set up. The successes here have been less than brilliant. Thermonuclear research, for example, is going through a period of some stagnation. The appearance of the first commercial thermonuclear power stations is expected only by the third and fourth decades of the next century. Still to be solved are complicated technical and manufacturing problems.

A great many hopes are tied to the large-scale use of the solar energy falling on the Earth. The power of our luminary is enormous in scope and is ecologically clean. There are no harmful releases during its conversion and use on Earth, the environment is not polluted, and no additional warming of the planet occurs. The entire volume of electric energy generated in the USSR in 1990 could have been obtained from ground-based solar power stations with a total area of around 10,000 square kilometers. That means that approximately half of the solar energy falling on the Crimean Steppe over the course of a year and converted to electric energy would be able to meet the current demand of the entire country for electricity.

On a limited scale, solar energy is already being used in our country for the needs of the national economy: for residential heating and lighting, for pumping water from wells, and for supplying power to self-contained information systems—beacons, buoys and control-signal devices. In North Osetia, for example, an electric cattle fence has been developed which is powered by a solar unit, and it completely eliminates the herder's hard labor. The fence is characterized by exceptionally low power consumption. In operation in the Karakumy is a large solar complex which is producing heat and electricity. The complex is simple to use, does not pollute the environment, and the expenditures for its construction and operation were small and will be recovered within two-three years.

The first solar power station with a net capacity of 5 MW has been tested in the Crimea, and the country's first solar-powered metallurgical furnace for producing ultra-pure metals has been constructed and placed into operation near Tashkent.

The solar power stations operating in many countries use a thermodynamic energy-conversion method. That method replicates the operating principle of the ordinary heat and electric power station: a working medium such as water is heated up in special concentrated-solar-radiation collectors—boilers. The steam that forms is sent to a turbine which turns an electric generator connected to it. The boiler receives the energy from numerous mirrors—heliostats which automatically track the Sun. The commercial costs of the electricity generated by our domestic tower-type pilot power stations exceed the costs of power generated by thermal and nuclear power stations. But, at a number of ground-based solar power stations, high technical-and-economic indices have already been attained. In the United States, in the Mojave Desert, the first commercial power station using solar energy has been placed into operation. By introducing manufacturing and design innovations, the system's developers managed to reduce the cost of the electricity to eight cents per kilowatt-hour, which matches the cost of electricity generated by nuclear

power stations. The possibilities offered by solar power stations are only now beginning to be discovered, and such stations have a great future ahead of them. The time for using solar energy on a commercial scale has arrived. Humanity's most distinguished minds have dreamt about the widespread use of the Sun's energy on Earth. The great Russian physiologist, K. A. Timiryazev, directed the attention of the scientific community to the inept use of a primary resource—sunlight. In his well-known work, *The Sun, Life and Chlorophyll,* he wrote the following: "Each ray of the Sun that is not caught by us, but is, rather, reflected back into outer space without a trace, is a piece of bread torn from the mouth of a distant descendant." The prominent Russian philosopher, P. A. Florenskiy, in examining the world's energy reserves, came to the conclusion that it was necessary to make widespread use of solar energy (see the article "The World's Energy Resources" in the magazine ELEKTRIFIKATSIYA, No 1, 1925). Nobel Prize Winner Frederic Joliot-Curie, addressing a meeting of the Economic Council on the Use of Atomic Energy in May of 1956, said this: "It is now already necessary to be concerned seriously with the problems in the use of solar energy. Only experiments on a large scale can substantially improve methods for using the energy of solar radiation. I reiterate that this is a highly important task...."

That time, about which the scientific zealots dreamt, has arrived. Ground-based solar power stations are becoming competitive with nuclear plants. However, in the specialists' opinion, ground-based solar power-generation at the current stage will not be able to replace present-day systems. It would be a great achievement if, within 50 years, we managed to provide 10 percent of the world's energy needs through ground-based solar power-generation. Solar power will remain an auxiliary power system for a long time. The reason for that lies in the low level of flux of the energy of solar radiation on the Earth's surface, the intermittent nature of the electricity-production process, and the large capital outlays that are required. Moreover, manufacturing the needed equipment requires a large amount of various raw materials, subsequent treatment of them, and production of a final product, and that is accompanied by substantial environmental pollution. Ecological restrictions make it necessary to develop new, waste-free processes, which in turn requires additional capital investments and inevitably lowers the rate of commissioning large-scale ground-based solar power stations. It is possible that new, efficient, inexpensive, easy-to-set-up, simple-to-service ground-based solar installations will be developed in the near future. But for the time being, there have been no revolutionary achievements in that regard.

More and more, inquisitive human thought is being directed toward the problem of improving the efficiency associated with the use and conversion of solar energy on Earth. Under development are unique solar collection systems which will make it possible to produce high temperatures during the heating of the working medium, the efficiency of the thermodynamic and photoelectric processes for converting solar energy into electricity is being increased, and the capital and operating outlays are being reduced. But all that is not proceeding as fast as the enthusiasts of solar power-generation would like.

A competitor with ground-based solar power-generation has appeared. It is still in its infancy—the attained level of net capacity for this new type of power unit is small, around 10 kW in all. But the competitor promises to grow into a formidable rival, it is rapidly building up muscles, and its whole life lies ahead of it. It is space-based solar power-generation, which will be discussed in the subsequent sections.

Solar Energy in Space

Reaction apparatuses will conquer limitless space for the people and will yield solar energy that is 2 billion times greater than that which mankind has on Earth.—K. E. Tsiolkovskiy

The founder of theoretical cosmonautics, K. E. Tsiolkovskiy, was the first person to focus attention on a generally acknowledged fact—that nearly all the Sun's radiant energy is irrevocably lost to mankind—and to begin to seek means for harnessing that energy. The liquid-propellant rocket invented by Konstantin Eduardovich [Tsiolkovskiy] would become, in the author's opinion, a real means for achieving spaceflight and would make it possible to send into space and to deploy there special devices for using solar energy. When the predicted space era began, the then-third Soviet satellite (May 1958) and the first American satellite (January 1958) were equipped with solar power units with photovoltaic converters.

After the launch of the first satellites, the well-known popularizer of aviation and space technology, the pilot-engineer N. A. Varvarov, who headed the astronautics section of USSR DOSAAF in the second half of the 1950s, advanced the idea of supplying Earth with electricity in unlimited quantities via specialized space vehicles—space-based solar power stations. Nikolay Aleksandrovich [Varvarov] persistently promoted the new concept in the press, on radio, and at conferences and symposia. Noting the potential and the significance of that new type of power-supply system, he wrote this in 1960: "Man's creative thought will direct its efforts toward the development of space-based solar power stations which will supply the inhabitants of Earth with electricity in unlimited quantities. That will facilitate a substantial savings of all types of fuel and a fuller satisfaction of energy needs." A wireless line for transmitting energy in the microwave band from Earth to an aircraft had been under development since the late 1940s by Professor G. I. Babat, a Soviet electrical engineer.

In his book *Profiles of the Future,* published in the early 1960s in New York, the well-known futurist and science-fiction writer Arthur Clarke examined in detail the prospects for using the Sun's radiant energy in space. In light of the low density of the energy flux near the Earth, Clarke noted the advisability of placing solar ray "traps"

in the immediate vicinity of the Sun, with subsequent transmission of the energy in a directed beam to Earth. We would note that, when approaching the Sun, the density of the radiant energy flux increases to a limiting value of 65 kW/m^2 from 1.4 kW/m^2.

Further major development of the idea of supplying Earth with energy from space is associated with the name of the American scientist, P. E. Glazer, erroneously considered in the West to be the inventor of the concept of space-based solar power stations. In his articles published in the years 1968-1973, P. E. Glazer fleshed out the theoretical appearance of a solar power station and described on the basis of actually existing prototypes two basic components of the power station: the solar power unit intended for catching the Sun's radiant energy and converting it into electricity, and the system for directed transmission (and reception) of the energy from space to Earth in the microwave band.

Interest in the idea of supplying power to Earth from space increased considerably in the United States in the early 1970s as a consequence of the energy crisis which gripped the country. The U.S. Department of Energy and the National Aeronautics and Space Administration (NASA) established during those years a broad program of basic preliminary planning and enlisted the leading rocket-space firms in the study.

In the USSR, research on large-scale space-based energy systems for supplying ground consumers has been conducted by scientific research enterprises and planning-and-design enterprises. The results of that work have been widely published in conference proceedings and in special journals and popular science magazines. As a result of the scientific, preliminary design, and experimental research conducted in the USSR and abroad, a large and interesting amount of material has been obtained which has made it possible to estimate the hardware and technical-and-economic characteristics of this new type of power supply system, uncover problems facing the development of solar power stations and associated systems, and evaluate ways and means for inserting the system into orbit, deploying it, and servicing it.

It should be noted that there are sound reasons behind the great amount of attention that the scientific circles in the world's industrially developed countries have devoted to the problems of supplying power from space to ground consumers. The fact is that collecting the radiant energy, converting it into electricity and transmitting it to Earth for use in a national economy have basic advantages over the ground-based method of using solar energy. Among them are the increased level of the solar radiation flux (on the average, the amount of solar energy falling on a unit of area in space is 10 times greater than that falling on the same area of the Earth's surface), the continuity of the power-generation process, the possibility of deploying structures with enormous dimensions, the minute perturbing loads, and the minimal environmental impact while the system is operating. That is why it is much more advantageous to "intercept" the solar rays in space than to "collect" them on Earth.

In order to avail ourselves of those advantages, it is necessary to solve complicated problems, the main ones of which involve the insertion of the power station's components into space, their assembly in orbit, and the servicing of the power station during its operation. It is well known that those procedures are very energy-intensive and expensive. The commercial cost of sending a single kilogram of payload from Earth into space atop U.S. launch vehicles is around $10,000; atop USSR launch vehicles, around $2,000-3,000. Those are very large figures. The placement into service of new, high-efficiency, heavy-duty freight and passenger launch vehicles that have a low specific cost for insertion and minimal environmental impact should be considered the key to the solution of the problem of developing space-based solar power stations.

In light of the high cost of transport operations, the large shipments of cargo from Earth to a geostationary orbit, and the ecological restrictions, developers of space-based power-generation systems have proposed constructing the power station from extraterrestrial materials—in particular, those taken from the lunar soil. The composition of the Moon's surface rocks has been adequately studied. They are rich in silicon, oxygen, calcium, aluminum, titanium, magnesium and other elements of the periodic chart. After setting up the mining of the minerals on the Moon and their processing and dressing, we can move to the production of the power stations' individual components—such as its silicon photovoltaic converters, truss structures, cables, and microwave devices. The components developed at the lunar plant would then be delivered to an orbiting assembly center located in a circumlunar orbit, for example, at the libration point 58,000 km from the center of the Earth's natural satellite. After construction of the power station, it would then be moved to a geostationary orbit. The economic gain from such an exotic method of building a power station could be expected to be considerable. Given the same initial mass, a rocket-space transport system which lifts off from the Moon could insert into a geostationary orbit a cargo 20 times larger than could a system launched from Earth. But to do that, we would need on the Moon operating mines, processing mills, and plants for the production of the power station's various components, as well as plants for producing rocket fuel, a fleet of launch vehicles, systems for launching and servicing the transport vehicles, and, finally, numerous service personnel. The establishment of such a diversified infrastructure on the Moon's surface is a task for the far future. A possible time frame is the second half of the 21st century.

Another promising area of the research on space-based solar power stations is associated with the placement of solar energy collectors into regions of increased solar

radiation. When a space-based power station is inserted into a circular circumsolar orbit with a radius of 0.1 AU (14.96 million km), the power of the radiant energy flux amounts to 140 kW/m^2, i.e., it is greater than the solar constant by two orders of magnitude. The preliminary designs of such a circumsolar power station have been worked out by Soviet and American specialists independently of each other. The basic results of the studies were announced at the 14th K. E. Tsiolkovskiy Lecture Series in the city of Kaluga (1979) and at the 5th Conference on Space-Based Manufacturing in the city of Princeton (1985). The contrast in the approaches lay in the different methods for building the power station. The Soviet specialists proposed constructing the plant from terrestrial materials and carrying out interorbital transportation using the plant's own power unit and sets of electric rocket engines. The American engineers examined a method for constructing a circumsolar power station built from materials on Mercury in a near-planet orbit, with subsequent transportation using a solar sail.

The dimensions of the solar collector of a circumsolar power station would be approximately 100 times smaller than those for a power station of the same capacity in a geostationary orbit. Correspondingly, the mass characteristics of the power-generating unit—the main component of the power station—would also be reduced. The basic problem with such a design must be considered to be the development of the system for power transmission and reception over astronomical distances. Advances in the development of high-powered, continuous quantum-mechanical oscillators make it possible to figure on the development in the future of an efficient system for directed energy transmission. Assuming that the oscillator's beam width at half power points is brought down to values on the order of 10^{-9} radian, the dimensions of the transmitting and receiving devices will not be very large at all. However, at present we have no way of determining even approximately when such an energy transmission system could be developed. The plans for circumsolar power stations are, in point of fact, of a futuristic nature.

Description of a Typical Space-Based Solar Electric Power Station

The structural appearance of a typical large-scale space-based solar power station has, for the most part, been determined. With a power system net capacity of 5 million kW, the power station will be an immense structure with a mass of 20-50 tons. The area of the solar collector, based on the low-efficiency, but simple and reliable photovoltaic method of energy conversion, will amount to around 50 square kilometers. The more efficient thermodynamic conversion method involves complicated systems, including rotation units, and a very material-intensive structure, but the dimensions of the solar radiation collector-concentrator for it will be substantially smaller.

A power station inserted into a geostationary orbit (an altitude of 36,000 km) "would hang" above one point on the Earth's surface and, being illuminated by the Sun around-the-clock, would generate electricity and transmit it to Earth almost continuously. Low-capacity solar power-generating units are successfully operating in geostationary orbit as part of communications satellites. What is fundamentally new is the system for directed transmission of energy via the "space—Earth" path. The transmission of energy to Earth from space is possible with microwave or laser emissions. The first method is preferable for a number of reasons: microwave emissions freely penetrate the entire atmosphere and are not daunted by fogs and storm-clouds. They have comparatively low losses during direct and inverse energy conversion. The transmitting antenna's diameter is taken to be equal to 1 km. The beam emitted by such an antenna would fall onto a receiving antenna, the diameter of which would be at least 10 km. Here its energy would be converted into a commercial-frequency electric current which would be directed into a country's power-generating system.

The advantage of the laser method lies in the forming of a narrow beam and in the small sizes of the transmitting and receiving devices. However, the efficiency of direct and inverse energy conversion is low, and the losses of a laser emission in the atmosphere are large.

The overall efficiency of the process involving the production, transmission, and reception of energy for the entire power system, including the space-based and ground-based sections, is estimated to be 5-20 percent, which includes the production of electricity at 10-30 percent and the transmission and reception of energy at 50-70 percent.

To insert just one space-based solar power station into a low reference orbit from Earth would take no fewer than 200 launches of heavy-lift cargo launch-vehicles whose lift capacity would be at least 200 tons. During the deployment and operation of a space-based solar power station, additional orbital complexes would be needed—cargo and passenger towcraft, assembly-and-erection stations and repair-and-maintenance stations, and a ground-based system control center.

The creation of a new type of power-generation system would require large expenditures. Just the development of a space-based solar power station, including the scientific research and experimental design work and the creation of the first full-scale model of the power station, would require $100 billion. That sum includes expenditures for the development of heavy-lift cargo launch-vehicles, interorbital towcraft, assembly-and-erection stations, and repair-and-maintenance stations. Deploying a system of 60 space-based solar power stations with the corresponding ground-based receiving devices would require an additional $1 trillion ($10^{12}$).

With a useful operating life for each power station of 30 years, a commissioning rate of two per year, and operating expenses of around $500 million per year for each power station, the expenditures for 1 kW of installed

capacity would come to $4,000-5000, and the commercial price of the generated electricity would be 8-10 cents per kilowatt-hour.

It should be noted that reimbursement of the expenditures for developing the system ($100 billion [$10^{11}$]) is not expected to begin until 20-30 years after the start of operations. That means a doubling of expenditures as a result of the need to make loan interest payments. The possibility of appropriating such monies will encounter enormous difficulties. We would remind the reader that developing the hardware for the Apollo program took $25 billion, and the system began operating eight years after the start of the work. Procurement of that amount of money in the 1960s encountered considerable difficulties which were overcome by the United States's political leaders on the wave of an anti-Communist campaign under a slogan of opposing the USSR's imaginary supremacy in space.

In light of the fact that an installed capacity of 1 kW for operating ground-based solar power stations costs no more than $1,000, and the cost of the power produced by them is four-six cents per kilowatt-hour, we can draw a fundamental conclusion to the effect that developing space-based solar power stations that are based on existing equipment or equipment under development is a bad idea.

On the whole, based on the results of the completed basic scientific research, the following basic conclusions may be drawn.

The creation of a system of space-based solar power stations to supply ground-based consumers with energy from space is an achievable, technically feasible task. However, the problems which must be solved in the process are serious and numerous.

By the middle of the 21st century, with the aid of space-based solar power stations, it will be possible to meet 10-20 percent of the needs for electricity for the world's industrially developed countries, and space-based power generation will be capable of becoming one of mankind's primary sources of electricity. Deploying a system of solar power stations in space will make it possible to establish a base for the industrialization of space and the development of extraterrestrial resources and will expand the possibilities for colonizing space.

Needed for the realization of the plans under consideration for large-scale space-based solar power stations will be immense capital investments, whose reimbursement will not begin for 20-30 years after the start of the work. That will cause an unprecedented strain on the economic system of the country which develops the system.

The existing uncertainties in the predictive assessment of the design characteristics of a space-based power-generation system and its accompanying complexes (first and foremost, the cargo launch-vehicles) make it impossible to determine with adequate reliability the technical-and-economic indices and efficiency of the system. By assuming optimistic figures for the relative parameters of the space-based power station, the ground-based receiving station, and the accompanying complexes, it is possible to obtain a lower estimate of the cost of the generated electricity on the order of 10 cents per kilowatt-hour, which does not make it possible to effect competition with traditional power systems.

At the current stage of the work, intolerably little is known about the ecological aspects of the program and the possible effects of the microwave emissions and the launches of numerous launch vehicles on the health of the people, on the Earth's animal and plant life, and on the climate.

Giving the program for the development of space-based solar power stations an international character will make it possible to build a more efficient system through the realization of optimal designs, spread the risk out, improve the marketing prospects, and eliminate the possibility of the economic dominance of the developing country.

The versions proposed in the 1970s and 1980s for the experimental, demonstration and small-scale space-based solar power stations are based on traditional planning-and-design principles and are distinguished by low efficiency and substantially uneconomical operation. The small-scale models of space-based solar power stations do not make it possible to support financing subsequent stages of the work.

The allocation of any appreciable amount of financial resources for the space-based solar power station program, even if it were to occur within the framework of an international program, seems unlikely in the near future.

Reasons for Low Economic Efficiency of Space-Based Solar Electric Power Stations

The cost of the installed capacity of space-based solar power stations is estimated, as has already been stated, at $4,000-5,000 per kW. In the opinion of certain specialists, that figure is an understatement and the expenditures for 1 kW of installed capacity could increase to $10,000 or more. In light of the fact that the specific cost of alternative sources of electricity is lower (for ground-based solar power stations, it is $1,000 per kW, and for thermonuclear power stations, it is $2,000-3,000 per kW), the advisability of developing a space-based power system becomes questionable. The question arises, Why, given all the obvious advantages of using solar energy in space, does the economic efficiency of the power system turn out to be low?

Let us examine the principal systems of a space-based solar power station—the solar collector and the energy transmission-receiving system—as well as the systems for sending the power station into space—the heavy-lift cargo launch-vehicles. The cost of the photovoltaic converters that are widely used and are intended to operate in space exceeds the cost of their ground-based analogs by a factor of more than 10. That is due to the need to

provide radiation resistance, the use of expensive materials, the complexity of the manufacturing process for producing the components, and the low output of the existing production lines. With the development of space-based solar power-generation, the difference in the costs will most likely be reduced; the prices for the photovoltaic converters of the same area will differ by a factor of 2 or 3 for ground and space applications.

A technically feasible, highly efficient wireless link for energy transmission and reception in the microwave band presupposes the deployment of large-aperture antennas (diameters of 1 km and 10 km, respectively). The manufacture and erection in space and on Earth of such Cyclopean structures require expenditures of many billions, which are completely lacking for ground-based power stations, because the generated electricity goes directly into the commercial network. A decrease in the size of the emitting and receiving devices and a reduction in the specific mass of the microwave oscillators and in their cost would make it possible to reduce considerably the specific capital expenditures.

Sending the space-based solar power station's components from Earth into a geostationary orbit is expensive. Today, the cost of inserting a payload from Earth into a low reference orbit is around $10,000/kg. Let us assume that, as a result of progress in rocket technology, that cost will decrease by two orders of magnitude and will be $100/kg. Then, with a specific mass for a space-based solar power station of 10 kg/kW (a mass of 50,000 tons and a net capacity of 5 GW), the relative cost of sending into space a single kilowatt of power will be $1,000/kW. Thus, just placing the solar power station's components into a low orbit will require expenditures equal to the total capital expenditures in the creation of ground-based solar power stations. The assumed specific cost of insertion ($100/kg) is an unacceptably low estimate. The paradox lies in the fact that, even if those maximum technical-and-economic indices are achieved, that will not make it possible to compete with ground-based solar power stations. There needs to be an additional reduction in the costs for sending cargoes into space, and, in order to ensure the ability to compete, the cost of transporting cargoes needs to be reduced to a figure of $20-30/kg, which is, for all practical purposes, unachievable on the basis of the reaction principles for accelerating large objects in the Earth's gravitational field.

The careful reader has probably turned his attention to the difference in the specific parameters of the space-based solar power station and the transport systems. If the characteristics attainable in flight or experimental models (a solar battery efficiency of 12 percent, a power transmission and reception efficiency of 60 percent, and a specific mass for the solar collector of 0.5 kg/m^2) are incorporated into the design of a full-scale high-capacity power station (5 GW), then the specific parameters of the transport system are close to the maximums for which the feasibility and time frames of attainment are vague at the present time. The reason for that lies in the lack of any kind of experience in developing or operating solar power stations and in the considerable amount of completed research on launch vehicles which makes it possible to predict improvement of insertion systems, as well as in the direct influence of the insertion cost on the capital expenditures for a space-based power system.

Determining the feasibility of developing full-scale space-based solar power stations and high-efficiency, low-cost launch vehicles will require a large volume of scientific research and experimental work, which moves the time frames for initiating the realization of the program well beyond the year 2000.

Solar Electric Power Stations and Their Impact on the Environment

Nature cannot ignore man, for he is tied to it by a thousand unbreakable threads: he is her son.—I. S. Turgenev

The negative impact of the power-generating industries on the environment is well known. Heat and electric power stations [TES], for example, burn valuable raw materials in their furnaces—coal, oil, or gas—which has accumulated on Earth over the course of a billion years as a result of complicated, not fully understood processes. The destruction of these reserves will be a crime against future generations. The operation of a TES is characterized by considerable thermal pollution of the biosphere. No less than 60 percent of the energy produced in the combustion of a hydrocarbon fuel dissipates uselessly in the atmosphere, which leads to an increase in the average worldwide temperature and has a negative effect on atmospheric dynamics and on weather conditions around the power station. As a result of fuel combustion, toxic products are formed—carbon monoxide, sulfur dioxide, nitrogen oxides, hydrocarbons, and particulates. Particularly large are the releases of sulfur compounds. The toxic products, as they enter the atmosphere, are having a disastrous impact on the Earth's animate and inanimate environments. For example, the operation of a TES involve considerable consumption of raw minerals and thermal and chemical pollution of the Earth's biosphere. The impact on the biosphere in the developmental stage of a power-generating system—during the production of the principal components, the transport to the construction site, and the construction itself—must also be regarded as an important parameter. The creation of a TES is characterized by a slight impact on the environment.

With solar power stations, the opposite occurs—there is a slight impact on the environment during operation and a large impact during the system's construction stage. Calculations have shown that a single space-based solar power station with a net capacity of 5 GW will require 500,000 tons of aluminum, 50,000 tons of silicon as the initial material for producing the photovoltaic converters, and 150 billion kilowatt-hours of electricity for producing the structural components of the station and the accompanying complexes. That can lead to a shortage of raw material and power for the development

of other areas of the economic system of the state which develops this new type of power system.

The deployment stage of a space-based solar power station will require conducting a large number of launches of heavy-lift launch vehicles. Given the time frame limitation of two years for constructing the space-based power station, the frequency of the launches of launch vehicles with a lift capacity of 250 tons will amount to no more than two days. In the process, more than a million tons of rocket-fuel combustion products, including nitrogen oxides, carbon monoxide and even water, will enter into the upper layers of the atmosphere. The consequences of such atmospheric pollution are unpredictable, but, obviously, they will be of a negative nature.

Another important aspect of the operation of the space-based solar power station is the electromagnetic fouling of the environment. The continuous transmission of energy from space to Earth in the microwave band will be a new factor of adverse impact on the biosphere. The maximum flux density of the power-generating beam at the Earth's surface is assumed to be equal to 23 mW/cm^2, and, at the edge of the rectenna, the density is reduced to a value of 1 mW/cm^2. At a distance of around 7 km from the center of the rectenna, the density will be reduced to a value of 10^{-2} mW/cm^2; that value corresponds to the Soviet medical standard for safe levels of a person's prolonged exposure to microwave radiation. The area within that circle may be declared restricted, with access limited to only service personnel dressed in special clothing. It is also necessary to do additional research on the impact of the electromagnetic radiation on flora, fauna, humans, and equipment. It is evident that the background radiation will create interference in the operation of the receiving equipment of radio and television systems.

On the whole, based on the ecological aspects of the construction and operation of space-based solar power stations, it is possible to draw the conclusion that its functioning in orbit will be accompanied by a slight impact on the environment, whereas the production and deployment stages are associated with considerable consumption of raw materials and energy resources and with a great deal of thermal and chemical pollution of the biosphere. The consequences of such environmental pollution are difficult to predict, and additional research is needed to clarify them.

On the Agenda—a Small-Scale Space-Based Solar Electric Power Station

From the romance of gigantic projects—to the practical considerations of real designs.—The author

There are two known alternate points of view on the course of further work on space-based solar power stations. The first proposes the development of space-based power generation for earthly needs be stopped completely. The second calls for a broad expansion of scientific research and experimental design work for the purpose of developing full-scale working models of power stations.

The negative view on the prospects for using space-based solar power stations is based on the project's high cost, the ecological uncertainty, the absence of efficient, lightweight, inexpensive solar-energy-to-electricity converters, and the disparity between the capabilities of rocket-space hardware and the demands that have been put forward. Academician Zh. I. Alferov, together with power engineers and economists, believes that, in fact, the space-based version of solar power generation has long since been "buried by economics. The idea...is completely unrealistic."

In the opinion of another group of scientists—including Dr Phys-Math Sci V. A. Vanke, L. V. Leskov and others—stopping the work on space-based solar power stations would be a big mistake. All the difficulties standing in the way of the project's practical realization can be successfully overcome. By the time the first working models of the power stations are constructed—and that would be in the third decade of the 21st century—the cost of electricity generated on the ground may increase to 20-25 cents per kilowatt-hour, in which case, space-based power stations will be competitive with ground-based power sources.

The dispute between the proponents and the opponents of space-based power generation is being waged at conferences and symposia and on the pages of special journals and popular magazines. In fact, the fate of an entire area of power generation is being decided; a mistake in the selection of the path for the further development of solar power generation could lead to losses amounting to many billions and could be reflected in the fates of future generations.

Settling the controversy is not a simple matter. Based on the technical-and-economic indices, space-based solar power-generation is substantially inferior to the traditional power sources. But the science is developing rapidly, and the equipment is improving. What is complicated and expensive to produce today, may become simple and inexpensive tomorrow.

We must sort things out objectively in this complicated question, in which the interested parties are occupy extreme positions.

The first, "nihilistic" position, with all the obvious expediency of the economics of the financial and material resources, could lead to stagnation in the technology, since it precludes the possibility of a technological breakthrough which would provide for the organization of a systematic scientific and technical search on the frontiers of the sciences and for the corresponding financing of the research. The second, "extremist" position presumes the construction of space-based power stations

with unprecedented dimensions and masses. The erroneousness of such an approach may be demonstrated by historical example. Suppose the State Commission for the Electrification of Russia plan had provided for the establishment of a network of power stations like the Krasnoyarsk GES [hydroelectric power station], capable of developing 5 GW of power, without the development and many years of operation of low- and medium-capacity power stations such as the Kashir, Volkhov, and Dnepr stations. It is obvious that such a plan would have been doomed to failure. There exist specific rules during the development of complicated technical systems and a sequence for performing the individual steps: the performance of scientific research and experimental design work and experiments, the development of smaller working prototypes, the accumulation of experience, the reimbursement of the expenditures for development, and, only after this, the transition to the construction of large-scale items of greater profitability.

The proponents of the "extremist" views do not take into account those strict rules, and they exclude entire stages from the program of operations. A different approach is proposed to the organization of the work on space-based solar power-generation. Underlying that approach is the principle of a step-by-step increase in the capacities of space-based solar power stations, with simultaneous assurance of the system's profitability. Placed on the agenda is the problem of the development of small-, medium-, and large-scale models of a space-based solar power station that generate 100 kW, 1 MW, 10 MW, 100 MW and 1 GW of power. Only after mastering a low level of installed capacity, obtaining the needed experience, and recovering the incurred expenses can one move on to the next step.

There are no fundamental difficulties in the development of the proposed series of space-based power-generating units. At the present time, the research associates of Scientific Production Association Energiya are developing a general-purpose space platform with a solar power-generating unit; the platform is equipped with the service systems needed for prolonged operation in space. It is possible to place on the general-purpose space platform various kinds of special-purpose equipment, including equipment that forms and irradiates a microwave beam in the direction of a ground-based receiving station. It has been reported in the press that the heavy-lift Energiya launch vehicle can insert into geostationary orbit a payload with a mass of 18 tons. Such a platform could become the base for building a small-scale space-based solar power station with an installed capacity of around 100 kW. The problem lies in creating a high-efficiency system for transmitting and receiving power with acceptable apertures for the emitting and receiving antennas, as well as in ensuring the profitability of supplying energy from space to ground-based consumers.

A well-known design for a high-efficiency system for transmitting and receiving energy in the microwave band of the electromagnetic waves presupposes the deployment in space and on the ground of large-aperture antennas. With transmission distances on the order of 40,000 km, an oscillation frequency of 2.45 GHz, and a transmission path efficiency of around 90 percent, the product of the diameters of the transmitting and receiving antennas cannot be smaller than 10 km^2. For the basic version of a large-capacity space-based solar power station, antenna apertures have been selected equal to 1 km in space and 10 km on the ground. An attempt to reduce the dimensions of the antennas for small-scale power stations to acceptable values (for example, to 30 m and 300 m) leads to a catastrophic drop in efficiency to values amounting to a fraction of a percent. It is obvious that a system for directed transmission and reception of energy for small-scale power stations should be built based on other principles. The development of such a system, which would use small apertures, will open up the way to the development of small-scale space-based solar power stations which can be widely used in the national economy.

The national economy's need for low- and medium-capacity power sources is great. In deserts, in remote regions, in the Far North and on islands in the world's oceans, various production facilities are being set up, and supplying power to them by traditional methods is difficult, require large expenditures, and lead to environmental pollution. One such local production complex is a small mine in Yakutia, the delivery of fuel for supplying power to which is a complicated and expensive task. It is possible to set up right next to the mine a small receiving antenna, to which a beam of energy could be sent from space. The mine and the settlement adjacent to it could be supplied with electricity from space continuously, around-the-clock. If the specific capital expenditures amount to around $1,000 per kW and the cost of the electricity does not exceed 50 cents per kilowatt-hour, then the construction of such a power station becomes appropriate.

Structural Design of a Small-Scale Space-Based Solar Electric Power Station

All the various structural designs for a small-scale space-based power station can be divided into two classes. The first includes all the versions for the structural design of high-orbit power stations, while the second includes all those for low-orbit power stations. A space-based solar power station in a high orbit (geostationary, geosynchronous diurnal, etc.) would generate electricity almost continuously, would remain for a long time in favorable conditions of line of sight with the ground receiving station, and, consequently, would be able to transmit energy from space to the ground continuously.

A low-orbit electric power station would have a circular or elliptical orbit which would be constantly illuminated by the Sun and would pass over a given receiving station twice a day. Such an orbit is called a Sun-synchronous single-path orbit. The selection of an inclination slightly exceeding 90° would ensure the movement of the orbit's nodal line in a counterclockwise direction with an angular velocity of around 1°/day. That would make it

possible to follow the Sun's apparent movement relative to a non-rotating Earth. Favorable conditions of line of sight from the ground station would be created for very brief time intervals—three-five minutes. Accordingly, it would be necessary to include powerful energy storage batteries as part of the low-orbit power station and the receiving station. The power-generating system's operating conditions would be as follows: the power station would generate electricity continuously over the course of 12 hours, store it on board, and, as it passes over a receiving station, send the energy to the ground in the form of a microwave-emission beam. The ground station would receive the energy, store it in a battery, and, over the course of the next 12 hours, transmit it to a user. Such a cyclical mode of operation for a low-orbit power station would considerably complicate the design, lead to irreversible losses, and require the installation of on-board and ground-based storage batteries as part of the power-generating system. However, it would also make it possible to reduce the transmission distance from 40,000 km to 1,000 km. And that would lead to a substantial reduction in the requirements for focusing the microwave beam. With transmitting and receiving antenna apertures of 30 m and 300 m, respectively, the opening of the cone at half-power points, within which the energy beam must be placed, would amount to 0.7 second for a high-orbit power station and 28 seconds for a low-orbit station. As is evident, the focusing requirements would be reduced by a factor of 40.

Structurally, a high-orbit power station would resemble a geostationary communications satellite with solar panels. The panels would have to be able to track the direction toward the Sun, and the transmitting antenna would have to be aimed at the ground receiving station. Depending on the ratio of the masses of the power-generating unit and the antenna, an assembly with a large mass would be firmly fastened on the platform, while the steerable part would be connected to the platform with a special joint which would provide an electrical connection.

In the case of a low-orbit power station, the transmitting antenna could easily be made steerable, while the power-generating unit, firmly fastened to the frame, would be oriented toward the Sun. Well-known from the literature are the results of the preliminary design developments for a low-orbit, small-scale power station, done in the USSR, the United States and Japan. For reference purposes, we will list the generalized design characteristics for such a power station.

Table 1

	Project Developer-Organizations		
	Central Scientific Research Institute of Machine Building (USSR)	Institute for Cosmology (Japan)	Ad Astra Corporation (United States)
Power Station Characteristics			
Type of Power Station	Low-Orbit	Low-Orbit	High-Orbit
Net Capacity, in kW	500	10,000	500
Mass of Power Station, in Tons	70	200	5.3
Power-Generating Unit	10	180	3.0
Transmitting Antenna	20	10	1.3
On-Board Storage Battery	10	Included in Power-Generating Unit	—
Structure	5	10	—
Habitation Module	20	—	—
Reserve	5	—	1.0
Dimensions			
Area of Solar Panels or Solar Collector, in m^2	10^4	2.2×10^4	10^4
Transmitting Antenna's Aperture, in m	30	100	10
Relative Mass of Power Station, in kg/kW	140	20	10

As follows from the table, the concepts for building small-scale power stations are substantially different. Incorporated in the Soviet design are the actual specific characteristics, and in it, a great deal of attention is paid to systems for deploying and servicing the power station. Proposed in the Japanese design is a unique turbogenerator power-generation unit which includes an on-board energy storage battery. Lithium hydroxide has been selected as the working medium for the battery. However, in the design, the system for energy transmission and reception has clearly been inadequately studied. The American design is characterized by exceptionally high specific parameters, the attainment of which must be considered to be extremely problematic in the upcoming stage of the work.

Serious problems stand in the way of the practical development of small-scale power stations. Let us examine the possibilities for solving those problems.

Ways of Solving the Scientific-Technical Problems and the Organization of the Scientific Research Work

Let us give each other a hand
And move forward together—
And may our union get stronger
And grow under the banner of science!—A.N. Pleshcheyev

From among the entire set of basic problem questions requiring their own solution in the upcoming stage of the work on a small-scale space-based solar power station, it is possible to isolate four fundamental ones. They are as follows:

the theoretical and experimental substantiation of the practical feasibility of the proposed designs

the ensuring of acceptable mass characteristics for the power station's basic components

a reduction in expenditures for the development, construction, deployment and operation of the new type of power system

the ensuring of the ecological requirements and the compatibility of operating ground- and space-based electronic systems with the space-based solar power station

The practical feasibility of the proposed designs basically concerns the system for directed energy transmission and reception in the microwave band and is associated with ensuring a high level of efficiency for the transmission path with moderate apertures for the emitting and receiving antennas. With distances of around 1,000 km, transmitting and receiving antenna diameters of 30 m and 300 m, respectively, and a wavelength of around 1 cm, the path's efficiency will be equal to 30-40 percent and can be considered adequate. An increase in the transmission distance to 40,000 km with the same parameters would lead to a sharp drop in efficiency—to fractions of a percent. It would be necessary to have a substantial reduction in the energy beam's divergence angle, which cannot be done by traditional methods. Let us examine this problem in greater detail.

Let us assume that the transmitting antenna is built in the form of a phased array—a flat antenna made up of individual, precisely manufactured units—across whose area are uniformly distributed radiators which are leaky waveguides with built-in microwave amplifiers. Directivity is created through in-phase (in a single phase) interference of the waves emitted by all the antenna's components in one chosen direction. By assigning a strictly determined distribution of the amplitude and the phase for the transmitting antenna's aperture, we are able to form a narrow beam. Given a fixed wavelength, the energy beam's maximum divergence angle is determined by the transmitting antenna's size. The larger its diameter is, the smaller the divergence angle. In our case (a transmission distance of 40,000 km, a diameter of 30 m and a wavelength of 1-2 cm), the beam's divergence angle will amount to around 30 seconds; but it is necessary to have an angle smaller than 1 second.

Forming such a narrow beam is practically an insoluble problem. Is it possible to get around this physical limitation?

Well known in the theory of antenna systems is the so-called principle of superdirectivity. Out-of-phase interference of the waves in the main beam of the antenna array's radiators, which leads to total suppression of the emissions in all directions except one, will make it possible, in the opinion of radio engineers, to obtain small divergence angles. In the extreme instance, a beam practically devoid of divergence and diffraction should be formed. Scientists are conducting theoretical and experimental work. It has been reported in the press that a model experiment has been conducted in the United States in which a practically zero divergence angle has supposedly been obtained for an acoustic wave beam over small distances. Radio physicists and radio engineers have earnestly approached the problem, the solution of which would open up fantastic possibilities. The reception of electromagnetic signals would not depend on the distance between the transmitter and the receiver. It is obvious that a transmitting antenna which realizes the principle of superdirectivity would be constructed with aa complex structural design and would require complicated algorithms for controlling the electrical parameters for the aperture. The development of a transmitting antenna which would realize the principle of superdirectivity of the energy beam would mark the overcoming of a fundamental difficulty in the development of a small-scale space-based solar power station in high orbit and could be viewed as the No 1 task in the program for construction of a space-based solar power station.

A reduction in the specific mass characteristics of the space-based power station's basic components—the power-generating unit, the transmitting antenna, and the on-board storage battery—is a pressing problem of space technology. The attention of scientists and engineers has been riveted on that problem, and encouraging results have been obtained. Unfortunately, there have not been any significant successes with respect to a reduction in the specific mass characteristics of the transmitting antenna and the on-board battery. The phased arrays remain material-intensive, while the best silver-zinc batteries are characterized by a specific capacity in all of 150-200 W/hr/kg. In light of the requirements for mass balancing of all three basic systems of a low-orbit solar power station, the specific capacity of the on-board battery must be brought up to 800-1,000 W/hr/kg. Solving that problem must be considered to be the program's No 2 task. At the present time, a search is being conducted in many countries of the world for efficient, lightweight, inexpensive electrical energy storage batteries for a motor vehicle, which would convert it into an ecologically clean means of transportation. The development of the storage battery is the key to solving that urgent problem. It has been reported in the press that, in Japan, a storage battery has been developed on the basis of new principles and that the specific mass capacity of the battery exceeds by a factor of 30 the parameters of well-known types of storage batteries. Flywheel-type batteries are also being improved. This means that the prospect of attaining the required parameters exists.

It is well known that space hardware is extremely costly. Large expenditures are also required for sending payloads into space from Earth. The specific cost of American vehicles lies within the range of $50,000-$200,000 per kg. The complexity of the on-board systems for new types of vehicles and the increase in their reliability and useful life tends to increase the specific cost. The specific cost of insertion from Earth into a low reference orbit, based on international commercial rates, amounts to $10,00 per kg, and into a geostationary orbit, $50,000 per kg. Based on the fact that the relative mass of a small-scale space-based power station with a capacity of between 1 kW and 1 MW is equal to 150-250 kg per kW, it is possible to estimate the specific costs for development and insertion. They amount to $9-15 million per kW. Those figures are completely unacceptable. It is necessary to reduce substantially the costs for the power station's development and its insertion into space. Those problems are of industry-wide significance in connection with the plans for the broad industrialization of space and the realization of manned flights to the Moon and Mars. The search for means and methods for reducing the costs associated with the creation of space vehicles and their insertion into space from Earth may be designated as the No 3 and No 4 tasks. Ways of reducing the costs are obvious—a reduction in the amount of materials used in space vehicles, the use of available and inexpensive materials and technologies, a shift to high-efficiency reusable cargo transport systems, etc.

Another important task must be considered to be the resolution of the problem associated with the ecological restrictions stemming from the adverse impact of the microwave beam emitted from the small-scale space-based power station on the Earth's biosphere, on animals, and on man. With continuous energy transmission with a net capacity of 1 MW, the average power flux density will be equal to 10 mW/cm^2, which corresponds to accepted U.S. medical standards for a safe level of prolonged microwave emissions. The Soviet medical standard for a safe level of microwave emissions is substantially lower (by a factor of 1,000) than the American standard and is more rigid. Taking into account the Soviet standard's requirements, it is necessary to isolate the region of the receiving station, enclosing it in a restricted area.

With a cyclical mode of operation for the power station, the average power flux density at the moment of transmission will increase by a factor of 300 and will amount to around 3 W/cm^2. Given a brief impact of the microwave emission (two and a half minutes), the Soviet medical standard for a safe exposure level is taken to be equal to 5 mW/cm^2; with an hour's exposure, it is 0.2 mW/cm^2. The imposition of a restricted area will make it possible to satisfy the requirements for the safety of personnel located within the receiving station's area. The radiation level outside the area is safe.

The above-described scientific and technical problems standing in the way of the development of a small-scale space-based solar power station are not the only problems. Complicated questions will arise also during the assembling of the power station in orbit, its deployment and repair. The entire set of new and complicated questions may be divided into three basic groups—scientific-technical problems, technical-and-economic problems, and ecological-biological problems. Those questions may be most effectively solved within the framework of an international program. Such a program of scientific research work, preliminary design work, and experimental work would make it possible to attract intellectual resources unprecedented in scope and to use the most advanced know-how in the development of new equipment.

At present, interest is being displayed throughout the entire world in space-based power systems intended for supplying energy to Earth from space. In the United States, the Sansat Energy Council has been formed, the purpose of which is the coordination of the research being conducted on the subject of space-based solar power stations. In the USSR, a "Solar Orbital Power-Generating Stations" section has been established under the USSR Academy of Sciences' Scientific Council for the Integrated Problem of "The Search for New Ways of Using Solar Energy." In France, work on space-based power generation is being watched over by the Committee for Electrical Energy and Space, established under the Society of Electrical and Electronic Engineers (SEE); in Japan, scientific developments are being pursued by the Tokyo Institute for Cosmology.

Cooperation in the efforts of scientists and engineers in the field of space-based power generation is currently a vital task. Today, an integrated international program of scientific research and preliminary design may be worked out for the period 1992-1995 on the subject of small-scale solar power stations. It would be best if the financing of such research were from UN funds, in light of the personal stake that all humanity has in the exploitation of solar energy in space for the needs of Earth. Such an international program would meet the deep-seated interests of the peoples of the world and would contribute to the development of trust and mutual understanding between countries. At the International Conference on Space Research planned for 1991, the USSR's representative will call the attention of the scientific community to a program for such work, will indicate the sequence for the fulfillment of the basic stages, and will offer proposals on forms of information exchange, as well as on a structure for management of the development work. For use within the framework of the program, the USSR can offer a whole arsenal of high-efficiency rocket-space equipment, the Energiya launch vehicle, the Mir station's base unit, supply ships, and, the main thing, its unique, many years of experience in operating a manned station and a variety of facilities in a low, near-Earth orbit. There is no doubt that other countries of the world will also be able to offer interesting studies and promising designs for the power station's most important assemblies and units.

A Small-Scale Space-Based Solar Electric Power Station and the Danger of the Militarization of Space

Scientists know that science cannot be guilty. The only ones guilty are those people who misuse its achievements.—F. Joliot-Curie

At first glance, the opinion may be created that a small-scale space-based solar power station could not have any kind of relationship to "Star Wars" plans or to the Strategic Defense Initiative program, within the framework of which space-based weapons are being developed—laser and particle-beam space stations, orbital interceptors, space mines and other means for conducting war in and from space. Despite the warming of the international climate, the United States is actively carrying out work on military programs and is contemplating the deployment of the first phase of SDI by as early as the late 1990s.

The proposed levels of power in the energy beam of a small-scale power station are sufficient for disabling radars, communications stations, and various receiving facilities. The orbital path of a low-orbit power station would pass over all the continents, and the energy beam generated by a high-orbit power station in geostationary orbit could be directed at large areas around the "parking" area of a facility on the Earth's surface. Thus, space-based solar power stations could become multipurpose vehicles: used during peacetime for solving national economic problems, and during wartime, as a beam weapon. There is nothing unusual in such dualism. An airplane can be developed for passenger transportation, but it can also carry an atomic bomb. A launch vehicle inserts into orbit around the Earth a satellite intended for scientific or national economic purposes, but it can also deliver into space a special weapon. The choice of a peaceful or a military application of the systems in space depends completely on the people standing at the helm of the ship of state, and it is determined by the political situation in the world and, in the final tally, by the results of the peoples' movement toward a nuclear-free, nonviolent world. Stopping the development of a radio-beam space weapon, being carried out under the fiction of the development of a space-based solar power station, is possible by placing under international control the research and development that is being done. When organizing the research, design, and experimental work for an international program, provision must be made for monitoring the activities of the developer and for stopping work on a possible military application of a system. Subsequently, that monitoring should be extended also to the flight-testing stage and the operating stage of a space-based solar power station. That would preclude the possibility of this new type of power-generation system being used for military purposes. International monitoring of research being conducted will become a reliable barrier to the military use of space-based solar power stations.

Conclusion

The creation of space-based solar power stations is, as the reader has been assured, a complicated problem. Theoretically, such a system can be created on the basis of the existing equipment and equipment under development, but its technical-and-economic indices are unacceptable, and the environmental impact which accompanies the development and insertion into space of the power station's components is also intolerably dangerous.

Needed are the development of new concepts for the construction of space-based solar power stations, especially small-scale ones, and a search for optimal designs which would make it possible to ensure the profitability of supplying a local ground consumer with power from space. Such a search is linked to the development of lightweight, inexpensive, efficient solar power-generating units and systems for directed energy transmission and reception and the creation of heavy-lift, economical launch vehicles. The solution might be found among nontraditional designs and new approaches.

Still ahead is the stage of broad scientific research work and experiments, which would best be carried out by scientific teams representing the interested countries of the world—the USSR, the United States, France, Great Britain, Germany, Japan, China, and others—in the context of a single plan and in close cooperation. The interest in such an international program on the part of specialists from the USSR and the United States is great. There is no doubt that the fulfillment of the program will yield a positive result and will open up new prospects. Focusing the planet's intellectual potential on this most important area will make it possible to obtain exceptionally effective results. The founder of the practical space program in our country, S. P. Korolev, characterized the process of the development of new equipment in this way: "That which was only a dream yesterday, becomes a workable problem today, and an accomplishment tomorrow."

In his poem "A Hymn to the Sun," the outstanding Soviet poet Leonid Martynov reflected the complexity of the process of seizing the Sun's energy, the difficulties of our existence, and the creative inspiration of man the creator:

O Sun,
My joy and my grief are you,
Soon will I get the better of you...
I,
The creator of power new,
With my will transforming
This world of pain and suffering...

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Project 'MAKS' Air-Launched Spaceplane

927Q0015 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 91 pp 19-26

[Article by V. A. Skorodelev, NPO Molniya, under the rubric "The Space Program": "Winged Cosmodrome"; first paragraph is source introduction]

[Text] **These days, when the cargo traffic to and from near-Earth space is steadily growing, we need to create space transportation systems that are cheaper and more all-purpose than those we are using now.**

From the Wing Into Space?

Occupying a special place among the various types of space hardware are transportation systems that are designed not only for putting payloads into orbit, but also for subsequently bringing them back to Earth.

Quite naturally, the first such space vehicles were the manned Vostoks in the USSR and the manned Mercury craft in the United States. A necessary condition for their development was that they effect the return of the crew to Earth. After that, orbital craft such as the Voskhods, Geminis, Soyuzes, and lunar Apollos and Zonds made their appearance in the USSR and the United States.

Their design was influenced to a considerable extent by the extreme conditions that would exist during reentry and braking in the Earth's atmosphere. High temperatures and accelerations and the strictest of weight limitations forces the developers of those vehicles to pare the number of recoverable parts down to a minimum. Those parts were, as a rule, the pressurized crew compartments, the heat shield, and a bare minimum of systems that enabled control during descent, provided life-supporting conditions for the crew, and enabled a soft landing. All the other component parts of the spacecraft were jettisoned and burned in the atmosphere. In the first stages of the exploration of outer space, such expendable hardware made it possible to solve a number of top-priority problems. Naturally, the cost attending the flight of such a craft was great, because that cost included all the expenses associated with the development of the launch vehicle and the spacecraft.

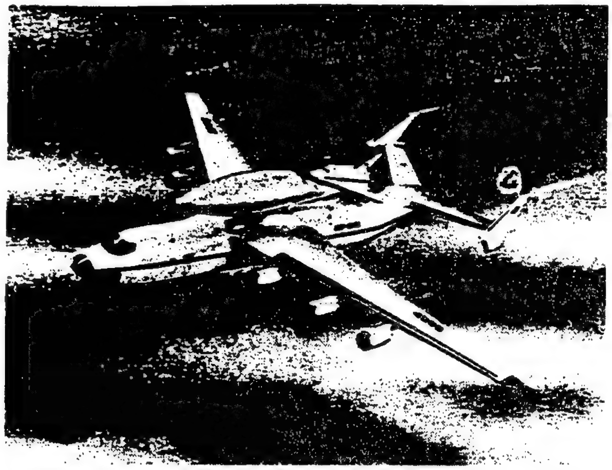
The first real attempts to lower the costs of the transport operation were made in the mid-1960s in the Soviet Spiral project and in the American Dyna-Soar project. Both projects proposed using a small, reusable orbital airplane capable of landing on an airport runway as the manned spacecraft.

In the American project, the orbital airplane was to be placed into orbit by a Titan 3 launch vehicle (operations in France in the Hermes project adhere to a similar profile). The Soviet Union, in the 1960s, developed the Spiral project, which made provisions for two versions of placing the orbital airplane into orbit: launched with a Soyuz launch vehicle, and launched by rocket booster from a supersonic booster-aircraft. The project got to the stage of development and flight-testing of a full-scale, manned version of the orbital airplane. The orbital craft was taken up to a high altitude by the TU-95 carrier-aircraft, after which it separated and performed independent flights in order to perfect stability and controllability during descent and landing.

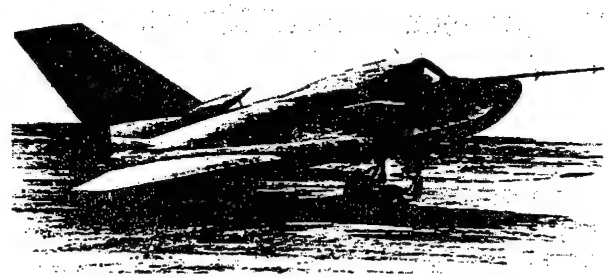
The Spiral project was being developed in the A. I. Mikoyan Design Bureau under the direction of Chief Designer G. Ye. Lozino-Lozinskiy. Various areas of the work were supervised by G. P. Dementyev, Ya. I. Seletskiy, L. P. Voinov, Ye. A. Samsonov, Yu. D. Blokhin, and Z. Ye. Bersudskiy.

The startup of the Shuttle program in the United States put a halt to the work in the Dyna-Soar project. The Spiral project in the USSR was also curtailed. With the creation of reusable systems—first the Shuttle in the United States, and then the Energiya-Buran system in the USSR—the flights of winged orbital craft became a reality. After performing jobs associated with orbital flight, the complex, expensive craft lands at an airfield. After operational checks are performed, it goes back into orbit. And although it has become possible to bring cargoes of considerable mass back to the ground from orbit, we have still not managed to lower the relative cost of lifting the payload, primarily because of the large number of expendable components that are used and the considerable volume of servicing operations that must be performed in-between flights.

The Shuttle and Buran are large spacecraft that are designed to carry large payloads. Obviously, those powerful, expensive systems are no good for tasks that require taking small and medium-sized cargoes to and



The design of a modern multipurpose aerospace system (MAKS). Takeoff mass of the entire system is 600 tons; mass of the spaceplane with fuel tank is 250 tons.



Manned experimental aircraft (full-scale model of the orbital airplane Spiral). Test flights in the atmosphere were done on it in the 1970s.

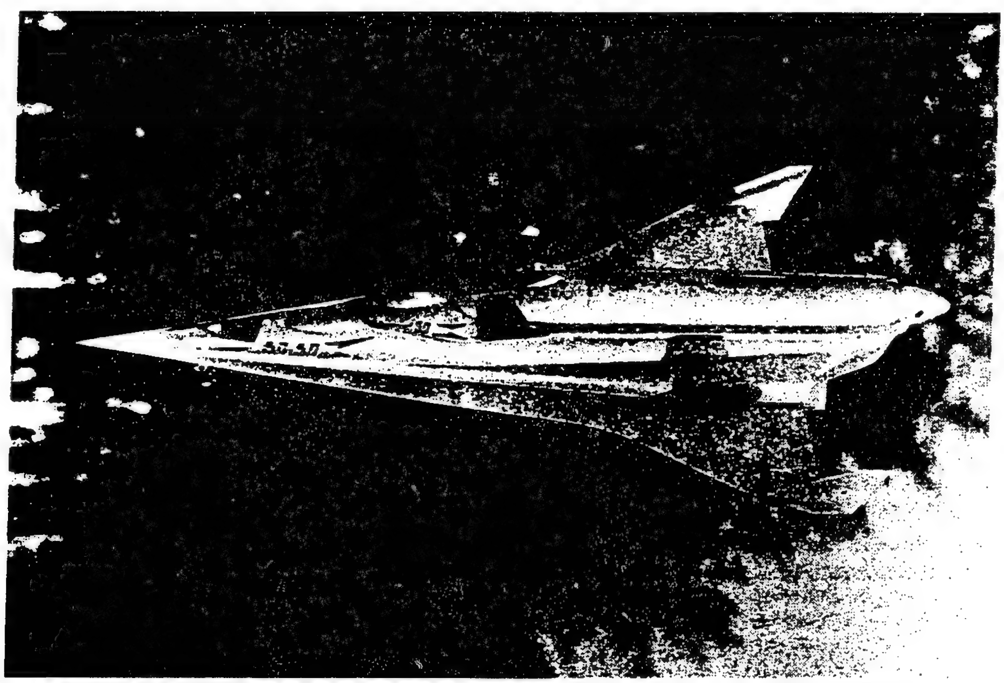
from orbit. Such tasks need a reusable, orbital airplane that has a smaller cargo capacity and costs less to operated.

A design involving a multipurpose aerospace system called by its developers MAKS and developed in the USSR by the Ministry of the Aviation Industry's NPO [Scientific Production Association] Molniya satisfies those requirements entirely.

The MAKS System Design

The aerospace system we're talking about is a logical extension of the Spiral design.

Thus, Spiral-Buran-MAKS represents a coherent, continuous chain of designs involving reusable space transportation systems. It is a two-stage complex in which the modified AN-225 Mriya carrier-aircraft, which at present is being used as a transporter of the Buran orbiter and the Energiya launch vehicle, is employed as the first reusable stage. When calibration and preparatory equipment are installed on it, the Mriya becomes a mobile launch pad capable of taking the second stage great distances from the base airfield and launching it with preset initial vectors of velocity and altitude.



Mockup of the Spiral complex—one of the first designs of an spaceplane system

The second stage consists of the reusable orbital airplane and an expendable external fuel tank filled with fuel for the sustainer engines of the orbiter. After separating from the carrier-aircraft, the orbiter performs independent flight similar to that of ordinary launch vehicles, along an injection trajectory into Earth orbit. Upon reaching a velocity near orbital velocity, the sustainer engines are switched off, and the external fuel tank separates from the orbiter and, entering the dense layers of the atmosphere, burns up almost entirely. The airplane itself, using its own fuel, enters its intended orbit and performs the tasks assigned it there. After completing its orbital operations, the airplane heads for one of the base airfields and makes a landing on a runway. During flight in the atmosphere, the airplane's good aerodynamics make it capable of changing its direction of flight considerably and landing at airfields that at that point are far from the plane of orbit. Thus, the MAKS design's use of traditional aircraft wings on the first and second stages makes it possible not only to make them out of reusable components, but also to increase considerably the maneuverability of the system during orbital injection and return to Earth.

It is possible, however, to make the use of that system even more efficient by also creating an alternative payload version. If in the basic version—i.e., orbital injection of the spaceplane with an inclination of 51°—its cargo hold can contain as much as 7 tons (as much as 8 tons in the unmanned version), the alternative payload version allows the system to put a payload of 17 tons into the same orbit. Thus, we see that the system that has been developed is, on the whole, capable of solving the problem facing similar systems—that of lowering the operational costs. It can be said with certainty that the relative cost of injecting a unit of payload will be five-10 times lower than with existing systems.

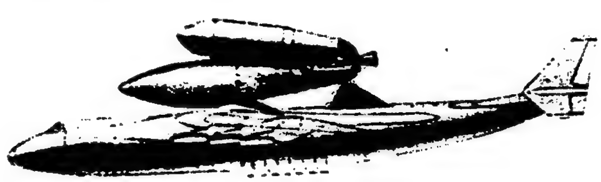
Possibilities Inherent in the Use of MAKS

As with any space transportation system, MAKS must solve a whole array of standard problems: delivery of payload to orbit, orbital operations, return of cargoes and crew to Earth. The orbital stage of MAKS can also be used to remove from orbit malfunctioning satellites and, after replacing them with new ones, returning the inoperative equipment to Earth for repair and, possibly, re-use. That would make it possible to revise the launch program for a number of satellites and to reduce their total number by eliminating backup models.

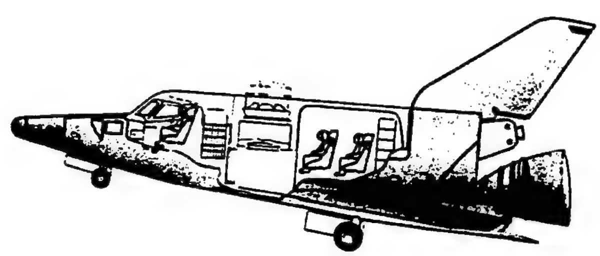
Mounted in the orbital airplane's payload bay could be various instruments for tasks such as mineral prospecting, day-to-day ecological monitoring, observation of the condition of ground vegetation, and astronomical research. That equipment could be used again and again on subsequent flights.

The next important task involves transportation-and-technical support of orbital stations. At present in the USSR, that task is being performed by the manned Soyuz-TM orbital craft and the unmanned Progress-M. The former delivers crew and small cargoes to the station, the latter delivers equipment, expended materials, and fuel. The recovery capsule of the Soyuz craft returns a crew and only a small payload to Earth, whereas the Progress craft is burned up completely upon reentry. Obviously, the MAKS can support a station in a more efficient manner. In order to do that, the orbital airplane is outfitted with special equipment mounted in the payload bay. That equipment comprises a docking module, a second pressurized cabin for transporting passengers and cargoes, or a fuel module for delivering fuel and expended materials to the facility being serviced.

Unlike the Soyuz, the orbital airplane is capable of returning to Earth not only a crew, but also substantial payloads in the form of valuable equipment and products produced on the orbital station. Operations on the Mir research complex, on previous orbital stations, on the unmanned Foton vehicles, and on the American Shuttles indicate the promise held by unique space-based technologies involving the manufacture in weightlessness of new, high-quality semiconductor materials, glasses, alloys, drugs, and protein crystals. But the fate of the development of those technologies again depends on the cost of transport operations, since merely performing unique experiments in the production of those valuable materials is not enough to make such production self-supporting. If a spaceplane system were used to deliver semifinished product to orbit and to return the finished products, such space-based production could become



Alternative payload version of MAKS. Mounted on the carrier-aircraft is an expendable second stage consisting of a fuel tank, a sustainer-engine propulsion system, and a large payload enclosed by a fairing.



Configuration of orbital MAKS airplane designed to deliver cargoes and crews to orbit or to perform emergency rescue operations.

profitable, and as a result, the number of orbital stations in orbit could be increased considerably.

Another version of the orbital airplane is the small orbital laboratory. The small orbital laboratory is similar in configuration to the orbital airplane that effects transportation-and-technical support, but it operates without the docking module. Mounted in the second pressurized cabin are various kinds of experimental equipment used for scientific research that is performed for science, medicine, and ground-based and space-based technologies.

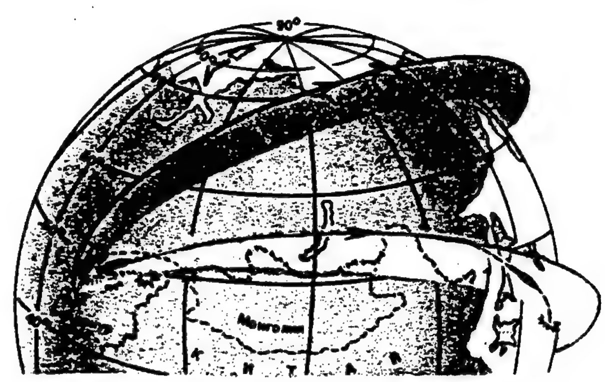
In light of the low cost of the launch, the small orbital laboratory could turn out to be more profitable than long-duration orbital stations for onboard industrial production of high-quality materials that have a short production cycle and require a large volume of replaceable equipment. The small orbital laboratory could also be used to perfect and test equipment for expensive space facilities for which the modeling of space flight conditions is completely impossible on Earth or is too expensive.

Yet another area of application of the orbital airplane for transportation-and-technical support could be that of emergency rescue of crews of manned space facilities. The rescue spaceplane would be outfitted with that same docking module and the second pressurized cabin, as well as with special rescue equipment and a large amount of fuel for supporting high maneuverability. The orbital spaceplane would have to be able to launch in a short amount of time, reach the orbit of the facility in distress quickly, and dock with the facility. Such rescue airplanes will be especially needed in the not-too-distant future, when many countries of the world will begin to develop complex space-based facilities, and a large number of manned space vehicles will appear in near-Earth orbit. Perhaps such a system of emergency rescue would best be created and operated on an international basis.

Other science- and national-economy-based tasks could possibly spring up in the course of the development and operation of a spaceplane system.

But Anyway, Vertically or Horizontally?

The multipurpose spaceplane system offers advantages over vertically launched injection systems (Shuttle, Energiya-Buran, Soyuz, etc.), which have a number of big drawbacks. The first such drawback consists in the considerably smaller payload allowed when it is inserted into an orbit that has an inclination lower than the geographical latitude of the launch site. The fact is that an orbital inclination no lower than the geographical latitude of the launch can be produced immediately during injection, and then, if need be, the plane of the spacecraft trajectory turned with great expenditures of fuel, reducing the inclination. The following example, involving the Shuttle orbiter, gives one an idea of the "cost" of such a maneuver. The standard 8 tons of fuel it carries for the orbital maneuver engines is enough to turn the orbital plane roughly only 2°. For our country, where a direct orbital injection takes a minimal inclination of about 51°, that



This illustration shows why, in the USSR, space vehicles vertically launched from Baykonur are not launched directly into orbits with an inclination lower than 51°. Spent launch-vehicle stages can fall only on the USSR or in the ocean. The inclination of the lower orbit is 51°; that of the upper orbit, 65°.

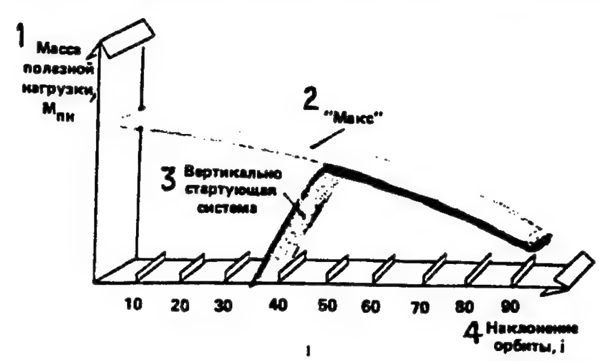
drawback is even greater than it is for the United States, which has a space launch facility at 28° N lat.

A spaceplane system handles that problem with a different profile. After taking off from a base airfield located in the high latitudes, the carrier-aircraft flies south with the second stage until it reaches a latitude that matches a given inclination. It turns to the east and launches the second stage, which is immediately placed in the plane of a given orbit.

Another drawback of the vertically launched systems is low efficiency in the performance of tasks associated with the rendezvous and docking of a craft launched from the ground and a vehicle in orbit. That also pertains to flights to an orbital station, especially in the emergency rescue of the crew of a spacecraft or a station performed by a special rescue spacecraft and for international monitoring of activity in near-Earth space.

An Efficient Rendezvous in Orbit. Is It Possible?

Let's assume that an emergency has occurred on some space-based facility. How soon can a crew of rescuers get



Key: 1. Payload mass, M_p—2. MAKS—3. Vertically launched system—4. Orbital inclination, i

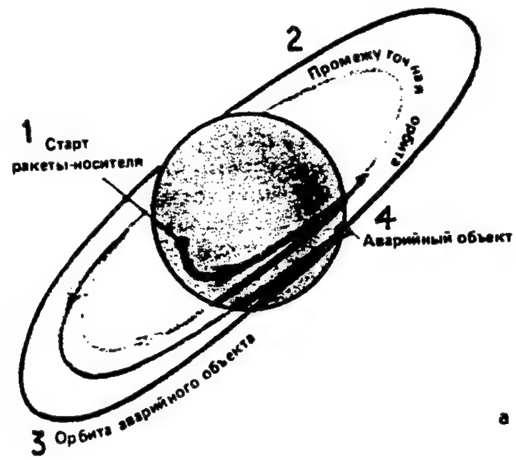
on board the facility? It turns out that the time needed for that is much greater than the time needed for preparing for launch and injection of rescue craft into Earth orbit. The laws of celestial mechanics are inexorable: in order for a vertically launched rescue craft to go into the emergency orbit, it must first be in the plane of orbit of the facility in distress at the moment of launch (and that plane is always shifting in relation to the Earth). Second, the positions of the rescuer and the facility in distress in relation to each other in the orbital plane must be just so. The process of coordinating the orbits is called effecting coplanarity, and the holding of the needed mutual positioning of the vehicles is called phasing.

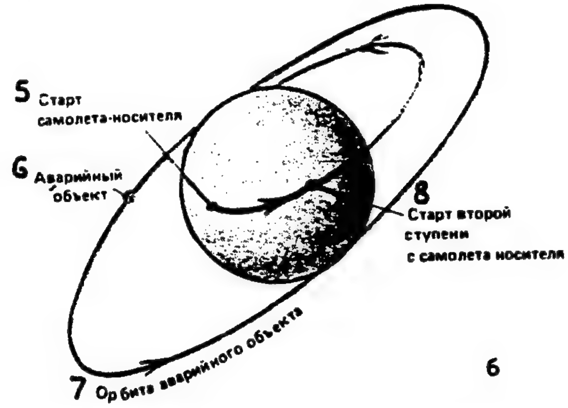
Effecting coplanarity and phasing could take as long as five days. Based on that, one can conclude that vertically launched systems are practically useless for performing the tasks associated with efficient rendezvous in orbit.

A spaceplane system can perform the job of effecting a rendezvous with a facility in orbit much faster.

After the report of an emergency is received, the spaceplane system takesoff from the base airfield and moves toward the plane of the orbit. Then the carrier-aircraft turns against the rotation of the Earth and remains in the plane of the orbit for as long as is needed to effect phasing (that time does not exceed the period of revolution of the distressed facility, which, for an orbit 400 km high, would be about 1.5 hours). Then the spaceplane is launched, and, bypassing the intermediate orbit, it immediately goes into the orbit of the facility in distress and makes a rendezvous with it.

For the sake of clarity, the processes involved in effecting coplanarity and phasing in a horizontal launch are shown sequentially. In a real flight, they would occur simultaneously, which means less time would be lost.





Profile of the flight of a rescue craft to a facility in distress in a vertical launch (upper diagram) and in a launch from a carrier-aircraft (lower diagram)

Key: 1. Liftoff of launch vehicle—2. Intermediate orbit—3. Orbit of facility in distress—4. Facility in distress—5. Takeoff of carrier-aircraft—6. Facility in distress—7. Orbit of facility in distress—8. Launch of second stage from carrier-aircraft

What's Next?

In some developed countries, a great deal of attention is being focused on the problem of creating a profitable space transportation system. Virtually all the designs include a reusable orbital airplane. Some of them call for the use of expendable launch vehicles as the first stage, and others have chosen a profile that uses carrier-aircraft. There are also designs for single-stage-to-orbit aerospace planes. Every design has a great many unsolved technical problems.

France, for example, is developing the Ariane V/Hermes system, in which the manned Hermes orbital airplane is placed into orbit by the expendable Ariane V launch vehicle (ZEMLYA I VSELENNAYA, 1989, No 2, p 48).

FRG is proposing a design of a two-stage, horizontally launched system—Saenger—with a supersonic booster-aircraft as the first stage and a fully reusable second stage (the orbital airplane Horus, equipped with sustainer rocket engines and tanks with fuel for them). The project also calls for a pilotless version, the Horus M, for injecting large payloads.

Similar work is being done in the United States (the NASP project), in Great Britain (the HOTOL project), in India (the Hyper-Plane), and in Japan (Hope) (ZEMLYA I VSELENNAYA, 1989, No 1, p 69).

And there are tangible results: in the United States, the first successful tests have been made of a system for injecting small payloads. The system consists of a B-52 carrier-aircraft and a winged, rocket-powered second stage, Pegasus, which can place small satellites into orbit. With the tight competition in the world market, many

firms from the developed countries are displaying great interest in the results of space research in communications, navigation, meteorology, prospecting for natural resources, global ecological monitoring, and production of high-quality materials and biological preparations in weightlessness in the hope of making a leap in technology through the use of the unique features of space flight. The path to that goal lies in the creation of highly efficient orbital transportation systems that have low operational costs.

In terms of level of development, the Soviet Union has the lead for now in that field. With adequate financing, a Soviet spaceplane system could be created faster than could foreign systems, and large profits would come in from its use in Soviet and foreign markets for transportation systems for developing near-Earth space.

Small Mars Rover Vehicle Tested

927Q0030A Moscow PRAVDA in Russian 17 Oct 91 pp 1

[Interview with Vitaliy Vernigora by Yu. Markov: "Ours on Mars?" the first paragraph is source introduction]

[Text] Vitaliy Vernigora, a young designer of the Scientific Testing Center imeni G. N. Babakin (a structural part of the Scientific Production Association imeni S. A. Lavochkin), participating in tests of the Martian rover, returned the other day from Kamchatka.

[Yu. Markov] For what reason did you go so far?

[Vitaliy Vernigora] In the central part of the peninsula, in the immediate neighborhood of the active volcanoes of the Klyuchevskaya group, is the scientific testing station of the St. Peterburg All-Union Scientific Research Institute of Transport Machines, the main organization for developing the chassis and automatic assemblies of the chassis of planetary rovers. The station includes a base headquarters in Kozyrevsk village and test ranges on the volcanic surface. The research carried out by this organization in collaboration with the Institute of Volcanology indicated that the surface of the fresh volcanic formations with its diversity of ground types and relief forms is an excellent analogue of planetary landscapes.

[Yu. Markov] What did you test?

[Vitaliy Vernigora] The chassis of a small Martian rover. The next stage in the tests was planned. It is true that the full program could not be carried out.

[Yu. Markov] Why?

[Vitaliy Vernigora] The Martian rover was taken for a little drive—there were trial tests, video, motion picture and photographic surveys, but on the next day such incessant gloomy rainy weather developed that the chief chassis designer, Professor Aleksandr Leonovich Kemurdzhian, after several days decided to depart.

[Yu. Markov] You said that the Martian rover is small....

[Vitaliy Vernigora] Yes, its mass is only 75 kg (the lunar rover was more massive by an order of magnitude). But its capabilities will be great and it will be a prototype of a full-sized Martian rover with a mass 400-500 kg. According to presently prevailing plans a small Martian rover should be landed on Mars in the second half of the 1990's, and a large one at the end of the century.

[Yu. Markov] How will the landing of the Martian rover on the Martian surface take place?

[Vitaliy Vernigora] By means of a parachute system and the velocity of impact with the surface will be extinguished by means of inflatable shock-absorbing balloons. The latter method is similar to the method successfully used in 1966 for the landing of automatic lunar stations on the moon. Thus, like a large soccer ball—a pushball....

[Yu. Markov] Can the developed Martian rover be compared with the lunar rover?

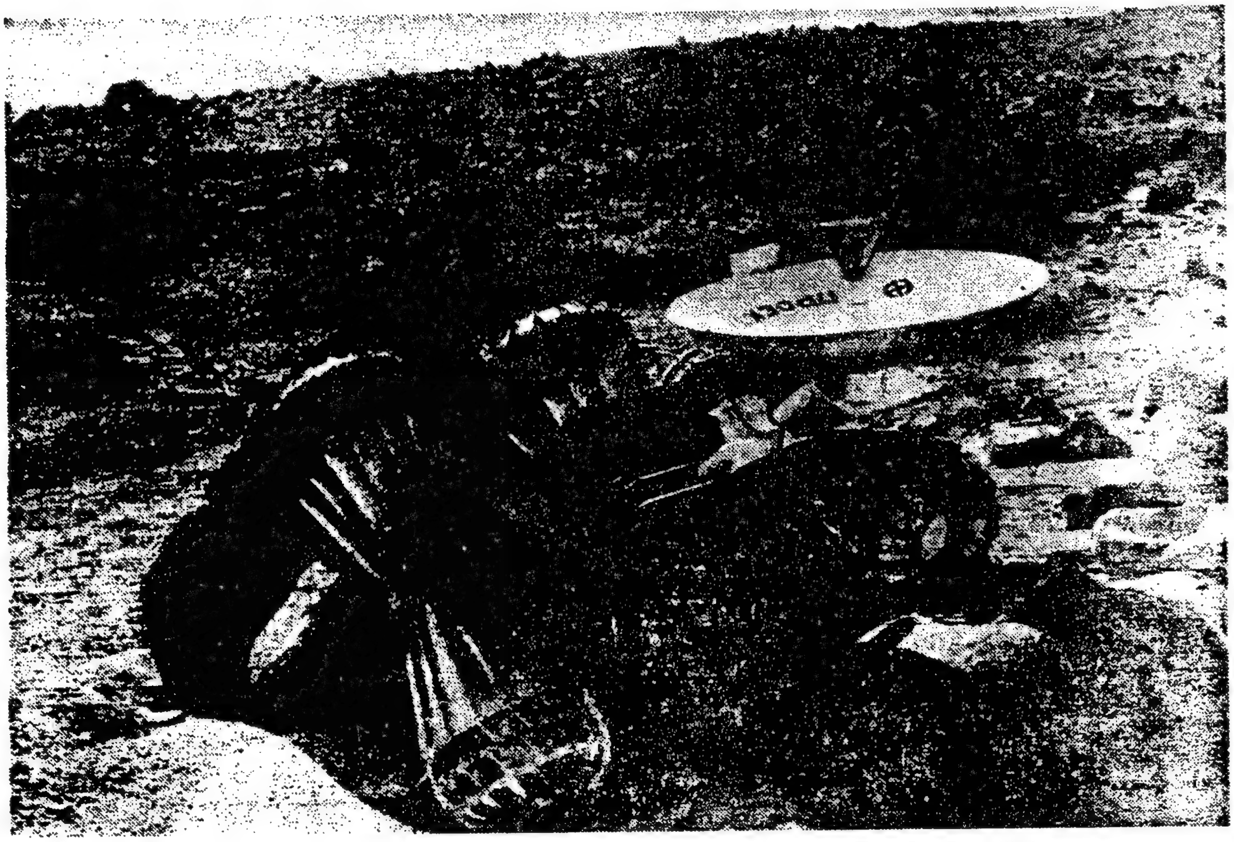
[Vitaliy Vernigora] These are fundamentally different machines! First, the chassis is completely different: a six-wheel engine with all drive wheels and an articulated frame. The wheels, with a diameter 350 mm, are of a conical-cylindrical form with grousers—elongated to such a degree that the pairs connect with one another almost without a gap. Thus, the concept of ground clearance and the possibility of getting stuck have virtually disappeared. In addition to operation on wheels, provision is made for a striding mode in which there is an alternate staggering of pairs of wheels. This makes it possible to overcome rises with unconsolidated ground material. And the articulated frame increases the height of a scarp which can be overcome by a factor two or more in comparison with a rigid frame.

Second, due to the great distance from the Earth to Mars autonomous and semiautonomous methods have been developed for guiding the Martian rover. A program (pattern) of movement of the Martian rover is transmitted to the vehicle and the detection and bypassing of obstacles not identified from the photographs is accomplished by the Martian rover using its own logic and its own equipment.

Third, an isotopic generator will be used not only for heating, as on the lunar rover, but also for producing electric power.

[Yu. Markov] Recently I became acquainted with a new issue of the journal of the American Planetary Society. One of the NASA projects is very similar to that described by you.

[Vitaliy Vernigora] Ours was patented long ago by the All-Union Scientific Research Institute of Transport



Machines. And why are automobiles, aircraft and rockets developed in different countries similar? It is the logic of development work.

[Yu. Markov] What are your further plans?

[Vitaliy Vernigora] In May of the coming year tests of the Soviet Martian rover in the American Mojave Desert are being planned.

Regulating the Temperature Conditions of a Sealed Container in a Spacecraft

927Q0021 Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 91 pp 69-72

[Article by O. G. Aleksandrov, O. V. Zagar, Yu. A. Ibragimov, V. R. Kazeyev, M. V. Krayev, and V. V. Nikitin]

UDC 629.19:66.045.2

[Abstract] The normal functioning of a sealed instrument container requires not only maintenance of temperature, but also creation of conditions for removing the excessive heat given off by the instruments themselves. One of the most economical ways of regulating the temperature of the atmosphere in a pressurized instrument container is to vary the amount of radiated heat by using louver doors. In a practical problem studied by the researchers here, the cylindrical surface of the container served as the radiation surface. A closed-loop ventilator circulated the gas inside, and the heat transferred by the gas from the instruments to the radiation surface was radiated to the ambient space. The louver doors, which were around the container and whose position relative to the container was changed automatically as a function of temperature, were driven electromechanically. Maximum temperature deviation did not exceed +0.5°C at 270 W. Use of a modulator in the regulation system made it possible to keep the time of operation of the drives smaller than the total time of operation of the spacecraft by a factor of 2×10^2. Figures 3, references 4 (Russian).

'Cosmos-2172' Communications Satellite Launched 22 Nov

LD2511133491 Moscow TASS International Service in Russian 1125 GMT 25 Nov 91

[Text] Moscow, 25 Nov (TASS)—The Proton rocket carrier launched another artificial earth satellite, Cosmos-2172, in the Soviet Union on 22 November. On board the satellite is equipment for relaying telegraph and telephone information, operating on centimeter wave length. The equipment is working normally. Incoming data is being processed by the computer coordination center.

'Raduga' Communications Satellite Launched 20 Dec

LD2012120591 Moscow TASS in English 1157 GMT 20 Dec 91

[Text] Moscow December 20 TASS—The Soviet satellite-launching rocket Proton sent the communication satellite Raduga into orbit today, carrying equipment for TV, telephone and telegraph transmission.

Raduga was launched in an orbit with the following parameters:

—Distance from the Earth is 36,500 kilometers,

—Period of revolution is 24 hours, 32 minutes,

—Orbital inclination is 1.5 degrees.

The onboard equipment is functioning normally.

The command-measuring complex controls the satellite's performance. The satellite's communication equipment will be run in accordance with the initial schedule.

Reconstructing Surface Wind Over Water in Regions of Atmospheric Convection From Satellite SLR Images

927Q0012 Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 (manuscript received 19 Jul 90) pp 26-32

[Article by M. V. Bukharov, T. V. Zakharova, and G. M. Ozerova, USSR Hydrometeorological Scientific-Research Center, Moscow]

UDC 528.873.044.1

[Abstract] Side-looking radar on oceanographic satellites is a system that is virtually all-weather and is one of the most sensitive not only for mapping sea state, but also for quantitative determination of the velocity of surface wind over water (given the wind direction is known). The researchers here set out to improve the techniques for acquiring quantitative data on surface wind in regions with mesoscale atmospheric convection, where there is great variability in the direction of the resulting surface wind vector. Their study is done in the context of a two-component model that presumes the presence of independent components of large-scale atmospheric transfer and roughly axisymmetric mesoscale atmospheric circulation. The example they present for the reconstruction of surface wind in atmospheric convection is an Okean satellite SLR image of convective cells in the Sea of Okhotsk that are behind a secondary cold front. They demonstrate that the reconstructed data on the direction of general atmospheric transfer and on extremal surface wind values do not contradict the ground data. The dimensions of open cells, as well as the nature of the convection in those cells, are found to change as a function of the mobility of individual sectors of the atmospheric front. Figures 2, references 5 (Russian).

Multiband Periodic Earth Survey

927Q0012B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 (manuscript received 22 May 90) pp 57-66

[Article by V. K. Saulskiy]

UDC 629.19:551

[Abstract] Multiband periodic Earth survey requires proper choice of satellite orbital parameters and satellite-system arrangement. The researchers here addressed both single-satellite and multiple-satellite survey in which the system observes the Sun-illuminated side of the Earth from one circular orbit, on the same track segment (ascending or descending). They develop a universal analytical method that makes it possible to minimize all the survey periods associated with the instruments carried aboard the different satellites. The methods is suitable for any number of satellites. Figures 5, references 5 (Russian).

Determining Duration of Satellite Imaging of Observation Area

927Q0012C Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 pp 67-72

[Article by Ye. A. Chevychelov, V. A. Lomov]

UDC 629.783:551

[Abstract] Satellite imaging duration must be determined in various design stages and in a priori evaluation of the efficiency of a space-based system for remote sensing of the Earth. If that duration is lengthened, and the swath of the survey widened, the amount of information provided by the remote sensing system increases—i.e., number of terrain features that can be observed by a moving spacecraft whose view is subject to illumination and cloud-cover constraints. The researchers produce expressions that can be used to determine imaging duration with the satellite equipment in pitch scanning mode, with a guaranteed linear resolution. Choosing the orbital parameters on the basis of

imaging duration analysis does not impose strict constraints on the design of the remote sensing system. The researchers recommend the use of their technique for the initial stages of the choice of the ballistic parameters of the satellite orbit. The functions derived with the technique can then be used in the synthesis of the ballistic structure of the remote sensing system with a geographic tie-in to a specific area. Figures 3, references 9: 8 Russian, 1 Western.

Determining Altitude Distribution of Ozone and Other Trace Gas Components of the Atmosphere From Satellite Microwave Limb Measurements

927Q0012D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 pp 73-81

[Article by K. P. Gaykovich, Sh. D. Kitay, and A. P. Naumov, Gorky Scientific Research Radiophysics Institute]

UDC 551.521.32:629.78

[Abstract] The growing anthropogenic effects on the environment have prompted researchers to devote a great deal of attention to problems involving the altitude distribution of trace gas components of the atmosphere, among them ozone. One of the most promising ways of monitoring such components is to perform limb observations by satellite in the radio range. Such observations provide a high resolution along the vertical, a large remote sensing range in terms of altitude, and an indication of relatively small amounts of various components (10^{-9}-10^{-7}). The advantages of such measurements consist in the negligibly small effect produced by aerosols and the applicability of the state of the local thermodynamic equilibrium through the entire altitude interval. The analysis of radio emission characteristics of the atmosphere that the researchers perform involves limb sounding near resonance frequencies for the millimeter range. Numerical experiments demonstrate that measurement error associated with radiobrightness temperature of 0.5 K is around 2-5 percent. In remote sensing of N_2O, radiobrightness temperature drops sharply as h grows, because of the rapid diminution of relative N_2O content. For that reason, the retrieval interval is limited to an altitude of around 40 km. Figures 5, references 25: 11 Russian, 14 Western.

Spectrum-Angle Method of Reconstructing Ocean Surface Temperature From NOAA Satellite Observations

927Q0012E Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 pp 82-88

[Article by N. A. Timofeyev, M. V. Ivanchik, and A. I. Sevostyanov, Marine Hydrophysical Institute, UkSSR Academy of Sciences, Sevastopol]

UDC 372.21.03.21

[Abstract] Determining ocean surface temperature with a greater accuracy than that achieved by current aerospace methods (1.5-2 percent) would enable researchers to approach a number of problems from a new angle—i.e., long-term weather forecasting, climate theory, global description of ocean processes, and rapid acquisition of information for fishing fleets and marine navigation. In wide-ranging experiments conducted with the r/v Akademik Vernadskiy (40-th cruise), a method was developed for the rapid reconstruction of ocean surface temperatures via NOAA-11 satellite observations in the spectral intervals of 3.53-3.94 μm and 10-3-11.3 μm. The mean rms error at scanning angles of 0-55° was 0.2-0.3° for cloudless states that corresponded to a surface temperature variability of 6-30°C. An atlas of ocean surface temperature maps was compiled for a portion of the North Atlantic in a geographic 0.5 x 0.5° grid system on the basis of 1987-1989 observations. Time averaging lasted five days to a month. Figures 4, references 16: 13 Russian, 3 Western.

Use of Materials Obtained With MSU-SK Scanner in Complex Study of Oil-and-Gas Areas

927Q0012F Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 91 pp 102-107

[Article by V. M. Pererva, T. I. Kostina, Kiev department, Institute of Geology and Fossil Fuel Development]

UDC 553.98:528.77:550.814+629.78

[Abstract] Since 1988, consumers of space-derived information have been using space images produced by the medium-resolution MSU-SK scanner. The images have been made at 0.5-0.6 μm, 0.6-0.7 μm, 0.7-0.8 μm, 0.8-1.0 μm, and 10.3-11.8 μm, with resolutions of 175 m and 600 m and a scale of about 1:2,500,000. The researchers here evaluated the geological information of those materials on the basis of images of eastern Georgia made 3 July 1988. They concluded that the materials can be used to study oil-and-gas areas at various stages in combined research involving structural-tectonic, neotectonic, petroleum-geology, and geomorphological regionalization, as well as the study of fault disturbances and zone of new fracturing. The researchers recommended that the materials be obtained from suppliers in digital form, with subsequent processing and conversion to photo carriers, with image amplification. Materials in analog form should be enlarged to scales of $1:10^6$, $1:5 \times 10^5$, and $1:3 \times 10^5$. The most informative images in terms of geological image interpretation were made at 0.7-0.8 μm and 0.8-1.0 μm. The researchers suggested that an image bank be set up for each region studied, with the images varying in time and season, type of imaging device, and type of survey.

IZVESTIYA Series on Problems of Soviet Space Program

927Q0043A Moscow IZVESTIYA in Russian 12 Dec 91 pp 1,3; 13 Dec 91 p3; 14 Dec 91 p 3; 17 Dec 91 p 3; 18 Dec 91 p 3

[Article in five installments by Yaroslav Golovanov: "Just Where Are We Flying To?"]

[12 Dec 91 pp 1, 3]

[Text] [First paragraph is introduction from page 1, under the rubric "'Izvestiya' Investigation"] **Perhaps the rubric ["Izvestiya" Investigation] is not quite appropriate for what I'm about to tell you. This is not the kind of investigation that Andrey Illesh conducted on the unfortunate Korean "Boeing." There are no timers, no radio intercepts. My investigation is an attempt to do some discussing, some comparing, some analyzing, and, thus, to investigate—more from the standpoint of logic than from the standpoint of criminality—the problems associated with the extreme degree of misfortune that has befallen our space program. For 30 years, I was a "space journalist" on the pages of our own KOMSOMOLSKAYA PRAVDA, but this time I'm betraying it, inasmuch as I must admit that of all our newspapers, IZVESTIYA is the newspaper that pursued that topic with the most consistency and with the most critical eye, to the great credit of Boris Konovalov and Sergey Leskov. That is why is was a pleasure for me to accept IZVESTIYA's offer to conduct this investigation.**

Part One

On the ramp from the Yaroslavl Highway to the main administrative building, at one end of the second story of which was his office, Sergey Pavlovich Korolev had installed a so-called mousetrap, which was outfitted with photoelectric cells. The car would approach the gates, and, as if in a fairy tale, they would fly open silently. As soon as the car had gone through, they would immediately slam shut, and you would be in a fairly small courtyard enclosed on all sides, with two small entrances from which the republic internal security guards were already smiling at you. The "mousetrap" was for the Chief Designer, his closest associates, and important guests, on whom all this silent technology made the proper impression—and Sergey Pavlovich loved to impress his guests.

On the morning of 16 April 1985, the "mousetrap" gates were working especially hard, letting in black Volgas and Chaikas every minute. Academician Valentin Glushko, chief designer of the NPO [scientific production association] Energiya, was assembling some highly placed guests, for a top secret, highly important meeting. At a long table in a room next to the small office of the academician were seated Grigoriy Romanov, a member of the CPSU Central Committee Politburo; Leonid Smirnov, first deputy chairman of the USSR Council of Ministers and chairman of the Military-Industrial Commission; the minister of general machine building (i.e., rocket building—by the way, who thought up the idiotic name "general machine building" anyway? That's like saying "general animal husbandry"); the future putchist Oleg Baklanov; a large set of people from the Central Committee, the military-industrial complex, and various ministries; and business people, namely, USSR Academy of Sciences Corresponding Member Gleb Lozino-Lozinskiy, the general designer of the NPO Molniya, and Vladimir Lapygin, the general designer of the NPO for automatic equipment and instrument making and the heir of the deceased patriarch of rocket instrument-making, Academician N. A. Pilyugin.

Glushko, after bowing his already gray head of neatly combed hair, reported in a monotone voice in his customary passionless manner that the launch of "item 11K77" (in plain language, the Energiya rocket) had gone successfully. Preparations were under way for the leak tests of the second stage on the universal test stand/launch unit, as well as the...blah, blah, blah.

A very experienced administrative in-fighter, Glushko knew that Romanov had only a vague idea of what the leak tests were, and the intentional monotonality of his report was intended to suppress any possible outbursts of indignation among the leadership. This time, however, he had made a mistake. Despite the upbeat coreport given by Lozino-Lozinskiy, who solemnly assured those at the meeting that the horizontal flights of item 11F35 (in plain language, the Buran orbiter) would begin on 28 May at the airfield at Ramenskoye, Romanov said in a stern, if not angry, voice that a bundle of money had already been spent and virtually the entire industrial potential of the country had been activated, but none of the deadlines had been met, and that meant that we couldn't match the American expansion into space with their Space Shuttles—never mind that the military was complaining about the payload shortfall. All that was really worrying the Central Committee and the Politburo, and, obviously, the issue needs to be taken up at the forthcoming meeting of the Defense Council...

Since ancient monarchal times, we in Rus have had this rule ingrained in us: the last word goes to the most important person. The most important person is the most intelligent and the most knowledgeable. And that rule is so deeply ingrained that we wouldn't think of it being any other way. How could it be possible for anyone but the most important person to "sum things up"? Is it acceptable for someone, after the "sum up," to interfere, not to mention object? Why, it's well beyond understanding even when someone just adds something! Why is that absurdity so tenacious? Is is possible to eliminate it?

What Romanov said was true, but they were things that were absolutely banal. In that room, there wasn't a single person to whom he had just reported anything that wasn't already known. It was absolutely irresponsible prattle at the highest level with individuals who were merely pseudoconcerned. As he departed the "mousetrap" in his long, black ZIL, Romanov was satisfied: "the

specified work has been done" (that kind of pedestrian apparat formula had existed for many years). He would report everything to the Politburo, he would tell how he had given them all orders, and now he imagined the smile that would come to the General Secretary's face, and the smiles that would soon follow on all the other faces. However, he would propound a strict "summing up," and in doing so he would remove from himself any responsibility ("I *told* them, I *warned* them...")—it would have to be discussed at the Defense Council, a draft of a decree would have to be prepared.... How many times now would it be that he had done something like that?

Napoleon advised that one should never give out orders if it were not absolutely certain that they would be carried out. No one here has listened to the emperor's advice. Worse than that, our Bonapartes were certain ahead of time that their orders would not be carried out. Let's perform a small chronological investigation.

On 17 February 1976, a decree was signed in the CPSU Central Committee and the USSR Council of Ministers concerning the creation of the reusable Buran space system. I wasn't able to ascertain who fathered the idea or who inspired it, because the father of an idea is announced only if his brainchild is an obvious success and offers every possbile kind of encouragement; but if things start to go wrong, the father certainly doesn't want to pay an alimony of billions of rubles. The overwhelming majority of the people close to the problem say that one must look for the roots of Buran in the Ministry of Defense. Indirectly, that is confirmed by two other decrees dated May 1977 and December 1981. Those decrees mention the tactical-technical specifications required by that very ministry for the vehicle in question. Many years later, Academician Roald Sagdeyev would say, "We traveled the path of the old stereotype that had come about—a symmetrical response."

Venomous tongues say that, after becoming familiar with the American Shuttle, the leaders of our armed forces became very afraid and ran to Marshal Grechko to try to talk him into building the same kind of airplane. The minister of defense very sanely decided that that would hardly be necessary. So then, going around Grechko, they began to use the Shuttle to frighten L.I. Brezhnev, and they explained to him that that damned Shuttle could zoom down on Moscow at any minute, bomb it to smithereens, and fly away. And they're all hoping that Leonid Ilich himself understands how much responsibility rests on his shoulders, the shoulders of the Marshall of the Soviet Union and Chairman of the Defense Council. Brezhnev understood. Yes, of course, an alternative weapon is necessary. And the work on Buran got under way. What is meant by "work"? Primarily, it means they gave money over for it.

Thus, Buran in its initial study was that very alternative weapon. How effective the Shuttle is, how capable it is of bombing Moscow we will leave for the military specialists to judge. But even if all that were so and Buran were needed as a response to a potential aggressor, a somewhat ticklish question arises.

In September 1969, right after the first landing of an American on the Moon, a long-range planning group at NASA released a report titled "The Next Decade of America in Space," which spoke pointedly about the Shuttle. At that time, NASA had signed the first contracts for a study of versions of an "integrated vehicle for launch and return." The question arises, why did we wait a whole seven years? In the past, the United States had passed us in the production of nuclear weaponry, but within four years, parity was reestablished. Such a brief period could in part be explained by the valuable information that we obtained illegally from abroad. With the Shuttle, no spies were necessary. We had entirely legal data on what the Americans were thinking of doing. And those who say that we copied Buran from the Shuttle are wrong. The external similarity is a tribute not to reconnaissance, but to aerodynamics. For similar problems, aerodynamics provides similar answers whether for communists or for capitalists—it just doesn't give a damn somehow. However, the first piloted flight of the Shuttle took place on 12 April (on the very day we designated International Day of the Space Program) 1981, before a single Soviet cosmonaut had ever gone aloft on Buran. So we're already behind by more than 10 years. If a reusable spacecraft is regarded as a weapon (and that's exactly how we regarded it at its birth), then that lag is monstrous and, for that reason, renders the weapon senseless.

Some examples of inspired, creative paperwork:

In December 1981, on the basis of suggestions made by the Council of Chief Designers—which at the time included, besides those who are still alive and well, the very experienced Valentin Glushko, Nikolay Pilyugin, Mikhail Ryazanskiy, and Viktor Kuznetsov—the CPSU Central Committee and the USSR Council of Ministers made it mandatory that all departments support putting Buran into service by 1985. The chiefs were representatives of the various departments, and it turns out that they were giving themselves an order, and that order was made into law by higher offices. Within just two months, however, advocates of the Stakhanov movement from the USSR Council of Ministers Commission for military-industrial issues were asserting their own general timetable for Buran, according to which the vehicle's first, pilotless flight tests were to be performed in the fourth quarter of 1984. But everyone knows that, for example, the volume of full-scale holddown tests of a launch vehicle constitute no more than 10 percent, and without them the rocket can't be tested on the ground or in flight, and, in turn, without the rocket how can one speak seriously about a Buran flight? And even 1985 was a totally unrealistic deadline. By that time, the project had "gobbled up" nearly 6 billion rubles (R), and barely half of the total volume of all the necessary operations had been performed. What has to be done in such situations? You guessed right! What else but issue a new decree!

The 2 August 1985 decree No. 750-222 of the CPSU Central Committee and the USSR Council of Ministers and the 25 August order No. 00100 of the Ministry of Defense set a date for the start of Buran flight tests—the fourth quarter of 1986. And that deadline was also pure "eyewash": the electrical tests of the orbiter didn't start until May 1986, and everybody knew that they wouldn't be over until the middle of December. And that's when Buran was sent to the production site, but not for launch—for assembly. Only 85 percent of its instruments had been installed, and only 25,000 of the 38,000 thermal-protection tiles needed for the design had been glued in place. Of the total flight-software structure, which contained 15 standard flight operations involving 198,000 commands, only three standard operations had been developed and were in place on the integrated unit.

So 1986 rolls around—the "year of the tiger" on the Eastern calendar—but the long-awaited leap still hasn't happened. On the other hand, a program of experiments on Buran up to the year 1995 appears and is approved by the CPSU Central Committee and the USSR Council of Ministers. For pity's sake, they're talking about experiments, and the vehicle hasn't even flown yet! I mean, let's just see first what it can do, and then come up with some experiments for the first two or three flights. But not plan 10 years ahead before we even have anything! Who gave the order to build 10 Burans right away? For what purpose? Wouldn't it be better to build two or three, "take them for some spins," and identify the flaws, find the mistakes, and *then* build the others? And do we really need 10 Burans? The United States built four, and they've all been aloft in space. Or is it just more of our go-get'em desire to outdo everyone and surprise them?

Korolev had an iron rule: criticism, discussion, and redesign were allowable up to a certain point. But after that, just do it. All the brilliant ideas were "for later," but an engineer who risked approaching the Chief Designer with a request to change the design felt as if his task were equivalent to trying to navigate across the Volga when it was completely frozen over. Between 1979 and 1987, more than 32,000 changes were made in the design documentation for Buran's airframe alone! Can we talk about quality here? And can we manage to explain why the building of such a unique design as our first space plane was assigned to the NPO Molniya and the Tushinskiy Machine Building Plant (TMZ)? I'm not trying to insult those renowned, talented collectives, but everyone knows that the NPO Molniya came about in the consolidation of two small design offices, Molniya and Burevestnik, who not only never had anything to do with the brainstorming about a space plane, but also had no experience in developing ordinary airplanes from start to finish. I'm sure TMZ will forgive me for saying so, but you can hardly call it a leading enterprise of the aviation industry in terms of its equipment, its production capacity, or its production know-how. That became crystal clear when the heat-resistant tiles were being glued onto Buran's airframe. Between 30 percent and 50 percent of tiles had to be reglued. During the assembly, as well as for other reasons, tens of thousands of tiles were ruined, and each of them cost R150-400 apiece. Ultimately, TMZ did not do well with the tiles: a great many had to be glued in place at Baykonur, at improper facilities, without the proper supervision of specialists, and, what's more, in a hurry, in a hurry, in a hurry. The main thing was to get it done!

Where to? For what purpose? Deadlines for the sake of deadlines, for the sake of getting praised? And in fact, that whole race wasn't just confined to Molniya and TMZ. If in the early 1980s, nearly 500 contractor-enterprises took part in the development of Buran, that number was nearly 700 as the mid-1980s approached and more than 1,500 by 1985, etc., etc. And the greater the number of people involved, the harder it became to assign blame. Add-ons, misrepresentations, and out-and-out fraud seemed to come about on their own, generated by the environment itself, by the nature of window-dressing itself. The horizontal flight tests of the first Buran, for example, in which the airfield landing had to be perfected, were set for the fourth quarter of 1981. It wasn't until November 1983 that the unfinished space plane—the airframe, essentially—was hauled from TMZ to the test airfield at Ramenskoye, supposedly to be prepared for flight. But it couldn't have flown, no matter how skilled its remarkable testers were: Buran hadn't been finished yet. As the machinists said, it was being finished practically "by hand."

In December 1985, Buran was taken to Baykonur, but it wasn't until the spring of 1987 that a new timeframe was assigned for its first flight—July-September 1987. And as we known, that deadline wasn't met, either. Buran wasn't really ready for another year.

On 26 October 1988, the State Commission named a final date for the first launch of Buran: 29 October 1988, at 0622. At 51 seconds before the launch, the automatic equipment gave a "System down": a platform with one of the attachment system components was moving away too slowly. Buran lifted off on 15 November 1988 and completed its first and only flight, in unmanned mode. And now what? *(To be continued)*

[13 Dec 91 p 3]

Part Two.

The principal difference between the Buran-Energiya system and the American Shuttle—a difference we're very proud of and have emphasized in a multitude of articles—is that the booster rockets for the Shuttle can't be used for anything else, whereas our Energiya rocket, which lifts Buran, is an all-purpose rocket. You can put Buran on it if you want, or you can put a satellite on it, or a lunar craft, or a Mars rover—whatever your heart desires. And that's all true. The Energiya rocket—item No 11K25 (a typo sneaked into yesterday's issue)—is in fact an advanced, all-purpose vehicle, but it's not without a number of flaws that we, guided by the longstanding traditions of rocket-and-space propaganda,

have preferred to keep quiet about. That didn't do us credit then, and it doesn't do us credit now.

Let's begin with the fact that the solid-fuel boosters of the Shuttle are more practical and less expensive than the oxygen-kerosene engines of Energia's strap-on boosters. The durability of the Shuttle's boosters, which is needed for solid fuel, is much greater than that required for parachute descent—that is a truly reusable part of the system, which, without any special expense, can be prepared for a subsequent flight. The thin-walled units of Energiya would hardly stand up to multiple use. In one very serious document, I read this sentence, which can be taken in only one way: "in the reusable Buran space system, the expensive control system, as well as the expensive oxygen-hydrogen engine of the second stage of the launcher, is unrecoverable, and it is doubtful that the problem involving reuse of its first stage can be solved." I can't corroborate what I'm about to say, and time will tell, but it seems to me that the only thing reusable in our "reusable" system will be Buran itself, and it'll mean a lot of fuss (and that means money!) to get it back out on the launch pad.

But if such difficulties attend the recovery of the units of the first stage, the question inevitably arises, Why did we choose liquid fuel over solid, which is what the Americans chose? It's hardly likely that they made the decision in what we call a "muddle-headed fashion." Liquid fuel is known to be more troublesome, servicing rockets that use it requires great skill, and keeping liquid-fuel units in a fueled state is incomparably more complex and expensive, never mind the fact that a solid-fuel rocket is simpler in its configuration, which means it's more reliable and more obedient to controls. Answering that question is rather difficult. There were subjective reasons for our choice: the recent General Designer of the NPO Energiya, Academician Valentin Glushko, was a confirmed opponent of solid-fuel rockets (which is entirely understandable to those familiar with his biography), and solid-fuel research, which grew to its height under S. P. Korolev—thanks primarily to the labors of Igor Sadovskiy—was (how can I put it a little more intelligently?) gently smothered. But there were also objective reasons. Liquid fuel is more energetic than solid fuel, and rocket thrust is greater. However, when it came down to a specific design, it turned out that liquid stages require more weight in the recovery systems, and that weight "addition" eats up the energy advantages of liquid-fuel engines. That is, it's exactly as Lomonosov said: "If you increase something in one place, you take something away in another place."

Finally, in terms of payload, Energiya still hasn't delivered what it promised. Newspapers have vaguely written that the payload the super rocket will deliver into orbit is "more than 100 tons." Let's get a little more specific: Energiya can lift, according to the calculations, 102 tons. But it won't. Tiny overruns in the mass of the structure and the individual assemblies—sometimes measuring just grams—combined to make tens and hundreds of kilograms during assembly. As a result, the overweight rocket can lift 7.5 tons less than planned. What is 7.5 tons? The launch weight of the fully fueled Gagarin spacecraft, with the cosmonaut, was 4,745 kilograms. The maximum weight of the Shuttle with payload, in orbit, is 117 tons. The estimates of the payload that our space plane can lift also put Buran behind the Shuttle. In an orbit with an inclination of 97°, the Shuttle can "haul up" 29.5 tons into space, whereas Buran can take 16. The maximum figure for the Shuttle is 36 tons (or in low orbits, as much as 45 tons); the figure for Buran is 30.

And nevertheless, for all those critical remarks, I want to note that both Buran and Energiya represent a success for us, an unquestionable achievement, movement ahead. They were the school we needed to improve ourselves. We were incredibly late with it, we did worse than we could have, we replaced the objective with the subjective, we put the interests at hand behind parochial and short-term interests, we displayed a certain laziness of thought and an atrophy of the will. But by God, we got the thing built!

The fact that Energiya went up right away, on the first launch, represents a great success and a great achievement, without a doubt. Even with the great Korolev, such was more the exception than the rule. The TASS report said that the rocket "took a mockup equivalent in size and weight to a satellite up to the calculated point." That was a lie. It wasn't some sort of cheap mockup, but an intermediate, partially equipped version of the Skif-DM space vehicle, which, on the one hand, served as a test payload and, on the one other, was intended for perfecting the design and onboard systems of a future military space complex with laser weaponry. Skif did not go into orbit. It fell to Earth and sank, or in the language of TASS, "that mockup and the second stage touched down in the designated region of the waters of the Pacific Ocean." (Such reports, in which "sinking" was called "touching down" and in which the salty abyss was called "the waters," would better have been given as poems in hexameter.) The joy attending the successful launch of Energiya was so great that it was somehow awkward to mention Skif. As for the bungling, the TASS report said: "The aims and objectives of the first launch were fulfilled completely." Does that mean that sinking Skif was among the aims and objectives of the first launch?

But let's put an end, once and for all, to all that carping and nipping. It's not dignified against the backdrop of what we've accomplished. The second flight of Energiya (also successful!!) lifted into space an unpiloted Buran, which later made a precise instrument landing. Joyfully, Oleg Baklanov, the secretary of the CPSU Central Committee, began to try to prove that the second flight of Buran should be piloted, but nobody listened to him, and it was decided to follow the program thoughfully and precisely. The program of 1985 called for performing 10 (!) flights over roughly three years, with the last eight carrying a crew of two or three people. But then three years went by, and not a single cosmonaut flew aboard Buran. In fact, the second pilotless flight never took place, either.

But suppose everything had gone well, even wonderfully. Suppose they had gotten the money they needed for the unfinished things, and all 10 launches had taken place without a single emergency situation, which would violate the laws attending the development of modern technology. Suppose the Mint had stamped out new gold stars and laureate medals, and candidates of science had become doctors of science, and doctors of science had become corresponding members [of the Academy], and corresponding members, academicians. There would be problems in the cosmonaut settlement with housing, and new homes would have to be built to accommodate everyone. In short, suppose everything had gone as well as it could have. Then what? What would we do after the tests had come to an end, and the stars had been hung around the necks, and the apartments had been given out? Just what would we need to do? What?

All of the history of technical progress shows that any machine, apparatus, or instrument that is created is created to solve a specific problem. Which problem was Energiya created to solve? IZVESTIYA has already published the sad story surrounding the creation of the N-1 super rocket. The disputes about the N-1 appear at first to be primarily scientific-technical disputes. But if you dig a little deeper and look a little more carefully, you see that they're not disputes that involve concepts—they're disputes that involve ambitions. Locked in hand-to-hand combat were several academicians—Korolev, Glushko, Pilyugin, Viktor Kuznetsov, Nikolay Kuznetsov, and high officials of the military-industrial complex and the army. The unfulfilled dream of Sergey Korolev, who died on the operating table—a dream that was decimated by Valentin Glushko, that was undefended by Vasiliy Mishin, and that took years of labor by Nikolay Kuznetsov—vanished in the gulf of ministerial paperwork and the flames of failed launches that turned billions of rubles into ashes. That's old hat, and, I'll say once again, it has already been written about, and we won't discuss here whether the N-1 rocket was good or bad or whether Korolev was right or wrong in his endeavor to pass the Americans on the road to the Moon. But Korolev knew full well what he needed the N-1 for—to fly to the Moon and land there. But for what purpose was the Energiya created? Yes, of course, our fleet of space rockets had clearly become out of date. Their developers were no longer even alive—S. P. Korolev, V. N. Chelomey, M. K. Yangel. Suffice it to say that the primary space rocket for manned flights—the Soyuz—was a modified version of Korolev's R-7, which was first launched in 1957. Like any other piece of equipment, a rocket requires not only updating, further modification, improvement of its most important characteristics, and increase in power, but also—and this is foremost and absolutely necessary—new scientific-technical thinking, improvement of the organizational techniques for solving the problems that are assigned, and comprehensive economic justification of of the designs being chosen. In other words, operations that are performed on the modern level of the development of the world scientific-technical revolution. Today, other General Designers have taken over the director's chairs of the deceased pioneers of the space program, but they have shown no desire to replace the organizational structures they have inherited, which in our rapidly changing times grow old faster than any structures could, because the new General Designers did not inherit from their teachers a clear idea of what they all—TOGETHER—are doing, when they are to do it, or what it will give them today and, what's more important, tomorrow and the day after tomorrow. That's why Korolev's "No. 7" has been flying for 35 years now, and Energiya is still trying to get some momentum.

Imagine if the BelAZ motor vehicle plant were assigned to build a 700-or even 1000-ton truck. Would they be able to do it? After spending oodles of money and endless labor, they could, I think, do it. But who would buy it? Who would want it to trample and destroy their roads, burning tons of fuel all the while? And most important, what would the buyer haul with it?

The General Designer of NPO Energiya (read: Korolev's design office), Yuriy Semenov, says this: "The development and operation of a new launch vehicle opened a new chapter in the exploration of outer space." That development got under way 15 years ago, and the operation of the launcher (if indeed it can be called "operation") got under way three years ago, but we have yet to see a single line from that new chapter. But then we're bound to see it sometime in the future. Nevertheless, I would like to ask what might seem a completely absurd question: What will we be "hauling" on Buran? What specifically?

Some will object, What do you mean "what?" The Shuttle hauls things up, and we'll be hauling the same kinds of things....

The history of the Shuttle is tragic for more than just the Challenger accident. One flight after another, it became increasingly clear that the shuttle craft is not capable of performing the tasks charged to it. A schedule that left the head spinning—60 flights a year—became, in reality, nine flights. But most important, the "reusability" of the Shuttle is not lowering the spending to anything less than what it would be with expendable rockets. For Shuttle modifications, the Americans have spent an additional sum of more than $2.4 billion, not counting the $1 billion spent for modifying it after the Challenger accident. The cost of a Shuttle flight is some 10-20 times higher than people initially thought it would be. Of course, our Buran, still in the embryonal stage of of its own development, is infected with the same disease. In the opinion of the very authoritative space specialist Konstantin Feoktistov, using Buran to lift payloads to satellite orbits and to deliver them to orbital stations will be 10-40 times more expensive than using expendable Soyuz and Proton rockets. According to other data, the Buran launch cost roughly 170 million rubles (R). Calculations show that that puts the cost of lifting one kilogram of payload of Buran at R6,000. If that payload were launched on a Soyuz rocket, it would cost a sixth as

much. We don't have to get exact figures for this much to be clear: for now, sending cargoes into orbit with Buran and Energiya is not economical.

I had occasion to read that Buran will make it possible to return from orbit very valuable satellites—for example, complex, expensive extraatmospheric telescopes. And here is what Aleksandr Dunayev, chairman of USSR Glavkosmos, suggests: "Nor should one forget that at present, certain satellites that are very expensive must remain in orbit after their service life runs out—and reusable ships can bring them back to Earth." Fairy tales for simpletons. And Aleksandr Ivanovich himself knows full well that not a single one of our "puny" satellites is so valuable that its return via Buran wouldn't be wasteful. And as far as I know, we're not going to have, in the foreseeable future, any satellites that would be valuable enough for that. By the way, General Designer Yuriy Semenov also feels that bringing satellites down from orbit with Buran would be economically unprofitable. But what other little jobs are being thought up for Buran? "We do not hide the fact that our plans include the docking of the Buran orbiter with the Mir station," says Dunayev. (Why would that in itself need to be hidden?) Surprisingly, however, he quickly adds: "But we feel that delivering a two- or three-man crew to the Mir complex is best done with expendable rockets." Pardon me, Aleksandr Ivanovich, for taking you at your word, but then it would turn out that Glavkosmos's plans are inadvisable, right? And here's another "by the way": Former rocket minister Oleg Shishkin has said that using Buran as a transport craft is uneconomical.

Finally, the effectiveness of the military use of Buran—something our press isn't "taken" to talking about—also raises some big doubts. Many specialists feel that the space plane doesn't fit tactical and technical needs, especially in terms of weight of the payload being launched, and is not capable, as had been hoped, of solving applied military problems on a fundamentally new level. When those military specialists began to compare the Shuttle and Buran in terms of a number of very important characteristics, things didn't turn out in our favor. You don't have to be a military specialist at all to understand that the length of time required for prelaunch preparations, the gigantic launch complex that is needed and that is simply impossible to camouflage, and the rather limited selection of azimuths for Buran keep it from being a "quick-response" weapon, and it's absurd to regard it as any other kind of weapon. But even if Buran could be regarded as an advanced weapon, such a weapon would have still been obsolete many years before its own birth.

In summing up everything that's been said, I would like to ask a simple question: Who can explain to me and to the millions of my countrymen—people whose money has been used to build that star plane—why we need it if none of the space systems that has been created or is actually under development can be put into orbit via Buran and Energiya or brought back down from orbit? There are eight individuals in the detachment of Buran pilots. Why do we torture those courageous test pilots with all those wearisome years of waiting? Anatoliy Levchenko died. Rimas Stankyavichyus perished. In the summer of 1984, Igor Volk was tested in space, and it was predicted that he would get the seat for the first Buran commander. When the great, now-deceased flier Sergey Nikolayevich Anokhin introduced me to Volk, he said, "Remember this man. If I'm a better flier than Petr Nesterov, that's how much better a flier Igor Volk is than I am." Think of how much that brilliant test pilot could have done in the past seven years! His flight on Buran would be, for me, a personal holiday, because here feelings prevail over reason...

And so, in looking at Energiya and Buran, we can't help but acknowledge that there are grounds for us to have a pessimistic view of our space future. But we don't have to be upset—after all, the huge Mir station is in orbit...

(To be continued)

[14 Dec 91 p3]

Part Three

The late 1970s and the early 1980s saw the rocket designers, the engineers, and the manufacturers loaded down with work. In addition to the giant projects involving Energiya, Buran, and Mir and its modules, plus the orbital spacecraft that delivered crews to the station and the transport craft that kept them supplied with everything they needed, there were operations involving the creation of the special satellites Raduga, Meteor, Nadezhda, Okean, Foton, Resurs-F, and Gorizont and the unmanned observatories Gamma and Granat, as well as the new Interkosmoses and the endless number of satellites in the so-called Kosmos series, under which name we chose to hide our spy satellites, plus the unmanned interplanetary probes that "went off track" and some honest-to-goodness innovations that we didn't want to report. Such a concentrated effort on the production of all that equipment could hardly have been sustained by any other country. However, others, of course, can't tell us what to do, and the communists could handle any problem (I remember well hearing songs on the radio that said that we had to work until our "hearts bled"). And so there was the race, the unmet deadlines, the un-thought-through things, as we chased after two, three, or even 10 rabbits at the same time, with results that are familiar to everyone. Even the mighty America, which is a thousand times more organized than we are, wouldn't do several major space programs at the same time: Mercury was replaced by Gemini, Gemini was replaced by Apollo, and then Skylab, and then the Shuttle.

Without a doubt, we raced ahead in the creation and operation of orbital stations. But in analyzing the programs attached to those stations, you often come across things that are hard to explain. I'm not talking about the trips involving cosmonauts from the former socialist countries. Those purely political acts have nothing in

common with science or technology. In light of the time it takes to adapt to weightlessness, the foreign socialist cosmonauts simply didn't have the opportunity to so any kinds of more or less serious work in the timeframes allowed for "visiting expeditions." It was clear-cut squandering of systems and technology for all the world to see. And it would have been OK if, politically, we had gained anything at all from it. But then we didn't gain any such thing, because our whole "policy" was built on the primitive belief that, for example, we would send someone from Poland into space, and Poland would love us for it. So we sent someone from Poland up, and he returned, and he donned the star we awarded such people, but for some reason Poland continued to not love us. We could throw barbs and snicker about it for a long time, but why do that? It's water under the bridge. And yet, echoes of it still bounce around today, and so we'll talk about it a little longer.

Many space specialists agree that some of the launches were performed merely for the sake of performing a launch. Launch, and then report about it. Demonstrate SIA—that's an abbreviation born at Baykonur and translated as an "Simulated Intense Activity." The Salyut-7 station was operational in orbit when we launched the Mir station on 20 February 1986. How does one explain such impatience? Was Salyut-7 obsolete and physically too old? Could we no longer work on it? No, that wasn't the case. How would you then explain the flight of Vladimir Dzhanibekov and Viktor Savinykh, unparalleled in its daring and its mastery?

The organized transfer of Leonid Kizim and Vladimir Solovyev from the Mir station to Salyut-7 on 5 May of that same 1986 appeared to be very effective. They had virtually nothing to do on Mir, and we kept stubbornly repeating that they were "the first people in the world to fly from one station to another." The farthest thing from my mind is to reproach Kizim and Solovyev, wonderful masters of their profession, for anything. But what was the purpose of that "first ever" flight? To tune up Salyut-7? I mean, it was clear that Ground Control did not have the capacity to control two orbital stations, change crews, and dispatch cargo supply craft. In the newspapers, we proudly wrote that, after completing its principal program in 1986, the Salyut-7 station continued to serve people for a long time. But we had nothing to be proud of: we were giving ourselves some insurance, because we had incorrectly calculated the service life of a huge, expensive vehicle. (If you remember, the same thing happened with our Lunokhod-1. It was supposed to last three months, and it lasted nine, and we also rejoiced about that.) In launching any space vehicle, we should have a clear, accurate idea of how long we will be able to work on it, what we will receive for that work, and by how much our income will exceed our expenditures. But there is no mention of that. We were unable to correctly estimate even the lifetime of Salyut-7 after the station was transferred to a higher orbit, our calculations being off by several years.

The Mir stations is called a third-generation station. It would seem that we have garnered some amount of "experience of the generations" that diminishes the probability of egregious errors. Yes, there are six docking ports on Mir, but just what is the sense of that? The station can operate productively and turn an economic profit only if all the scientific-research modules created for it are docked to it. But the station, which was launched in February 1986, has been flying "incomplete" for almost six years already. Because Mir's engineers miscalculated the weight of the station's cable system and made it heavier by 2.5 tons, many instruments had to be left on the ground and sent up later in cargo supply craft. At first, the science program for the cosmonauts was minimal, since there was no equipment there. But later, in April 1989, we interrupted the manned operation of the entire Mir complex, because the modules were not ready and there was nothing for the cosmonauts to do on the station. And at that very same time, there was a lively discussion in NPO [scientific production association] Energiya of a project involving a Mir-2 station with a 100-ton base unit. Clearly, six years is a long time for a space-based structure. Today, many of Mir's instruments and systems have been in operation two and a half times the service life set for them. The onboard computer broke down, which made it impossible to control attitude, which means impossible to conduct astrophyical experiments. The "metallurgy" units of the Kristall module have broken down. Kristall would obviously work more effectively in unmanned mode, since any movements made by the cosmonauts inside the station produce a change in the local gravity field, which does not facilitate the growth of high-quality single crystals. Over the time that has gone by, irreversible processes have taken place in the aging and wear of parts that are either very difficult or impossible to repair or replace: the cable system, pressurization seals, viewports, etc. It could happen that by the time the last brand-new module is docked to the station, the station itself could need to be replaced. Where on earth is there any real proprietary accounting here? Where is there even a weak attempt to produce maximum profit with minimum spending? The evidence points to chaos, a lack of coordination in what is being done, and a total lack of responsibility in all the programming.

The lack of automation, the unreliability and endless breakdowns of the equipment, and the dispatch aboard cargo supply craft of ever newer instruments and assemblies that require installation, checking, and adjustment all make the crewmembers of orbital stations freight handlers, riggers, assemblers, repairmen—whatever you want to call them—but not researchers! And if you consider that they live the lives of Robinson Crusoes, with nobody to look after them but themselves and that returning to Earth in proper physical shape requires training sessions that take a great deal of time, it becomes clear that cosmonauts simply don't have enough time to do research. Specialists estimate that

nearly 80 percent of the time a station crew spends working is spent on measures that involve life-support for the crew.

The most memorable episodes in the work performed by cosmonauts aboard space stations do not involve sensational scientific discoveries, or the detection of some previously unknown laws of nature, or the discovery of new objects in the universe, or the unlocking of mysteries of our own planet. They involve the correction of all sorts of malfunctions and failures. What really makes our cosmonauts true heroes is the imperfection of their space home, and stellar characters are forged in the crucible of the malfunctions that are constantly being found. Everyone remembers how Vladimir Lyakhov and Valeriy Ryumin, by performing an EVA, were able to free one of the docking assemblies of the Salyut-6 station from the KRT-10 radiotelescope antenna that was snagged on it, but who knows why the antenna got snagged on the assembly or which "hero" it was who made that snag possible. L. Kizim, O. Makarov, and G. Strekalov found themselves in what they knew to be an "emergency" situation when they were forced to change the panels of the hydraulic pumps in the heat-regulation system of that same station. That same L. Kizim and V. Solovyev made several EVAs to repair the Salyut-7 propulsion system. Finally, there's the unprecedented flight of V. Dzhanibekov and V. Savinykh to the dead Salyut-7 station. Everything there—from the severe conditions in the icy, uncontrollable station to the complex repair operations that required exceptional ingenuity and initiative and some unusual decisions—everything there was truly, without any newspaper embellishment, a feat. But a feat placed on the altar of someone else's incompetence, thoughtlessness, and lack of discipline. Who was punished, and how, for having forced our cosmonauts to perform those feats? I don't want blood, I want a fair glasnost. Person A and person B were in charge of the communications. A disappeared somewhere, and B left to have a smoke, and C, remembering that energy was supposed to be conserved, in muddling fashion disconnected the orbital station's receiver, and it wasn't able to receive any kinds of commands from Earth. So I'd like it if everyone knew who A and B are. Out of purely pedagogical considerations, for the edification of whoever is in charge of communications today and whoever will be in charge tomorrow.

In this age of scientific-technical progress, true scientific work requires a high degree of specialization and skills. Genuine discoveries are rarely made by dilettantes. A cosmonaut, no matter how smart he is, no matter how much you train him, can't be an astronomer, and a physicist, and a chemist, and a biologist. In the span of 30 years of manned flight, we have never once launched a scientist into space! During Voskhod, we wrote that a scientist, Konstantin Feoktistov, was part of a crew. For all the many years of respect I have for Dr Tech Sci Konstantin Petrovich Feoktistov, I have to say that he is, first of all, a brilliant project planner, designer, creator and tester of space hardware, engineer nonpareil, and only after that is he a scientist.

In the initial stages of the development of the space program, when every flight was in its own way an experimental flight, choosing spacecraft commanders from among fighter pilots was justified. And it was from among just such pilots that S. P. Korolev recommended the commander of the first Vostok be chosen. But Korolev, in fact, was organizing a group of civilian cosmonaut-engineers in his own design office. The years have gone by. And even today, of course, any space flight is, to some extent, an experimental flight. But who can explain to me why fighter pilots are spending months at a time on the station, instead of ecologists or astronomers? I want to be clear about this. The majority of those pilots are renowned, intelligent guys. I have ties with many of them through many years of friendship, and I have nothing against any one of them in particular. But can it really be that the Air Force, which got a mortal grip on our space program 30 years ago, does not understand that state interests do not always require the presence on the orbital station of someone in shoulder boards?

Every cosmonaut, whether military or civilian, has always been genuinely attracted to one scientific experiment or other, and it has turned out that they all have come up with some interesting results. But in actuality, no serious scientists (I'm not referring to physicians) have worked on orbital stations. Perhaps that partially explains the fact that research projects have never been completed and have never been done on time. That's true of peaceful and military programs alike. Over the entire existence of the Salyut-6 and Salyut-7 orbital stations, all the applied military experiments have been confined primarily to visual and instrument observations that accounted for only a very small percentage of the program itself, because, if we are to be absolutely frank, those observations were, you can be sure, not so necessary for either the KGB or the Ministry of Defense. Suffice it to say that 11 percent of the day-to-day requests for reconnaissance involving the locations of American aircraft carriers and warship detachments were fulfilled, as were 2 percent of the requests by the Main Intelligence Directorate of the General Staff and the Center for Space Reconnaissance for monitoring the "hot spots" on our planet. Plans called for Salyut-7 to be the base for important, long-term experiments involving, among other things, the observation of land and maritime objects (Kontrast-KRT), communications with submarines travelling at great depths in the ocean (Model-2), and space-based photo reconnaissance (Parus), but none of that was done. Even though there was certainly quite a bit of time and quite a few people: 26 crews worked on Salyut-6 and Salyut-7, and there were almost 50 months of manned-mode operations. I should note that the American space-based unmanned reconnaissance vehicles Aquacade and Chalet, just before the start of combat operations against Iraq, were switched to round-the-clock operation, and on the eve of air assaults by the U.S. Air Force, they provided a complete picture of possible activity of Hussein's air defense system and eavesdropped on staff orders and even conversations among tank crews.

But imagine the ideal situation: the station has managed not to age, all the research modules are docked to it, everything is in good order and is working well. We actually have an orbital, multipurpose laboratory. It's clear that the staff of such a laboratory must be bigger than what is usual for a station crew today (two or three people). How much bigger? Would five or 10 people be needed? How would that affect the life-support system? More raw materials would be needed for the experiments. More food would be needed. But more by how many kilograms? How many additional cargo supply craft would need to be sent? By how much would that increase all the operational expenses, and what would be the cost of the research that is conducted? I was unable to find the answers to any of those questions. Perhaps they exist, and I just didn't search very well. But that's not likely. I think that we just haven't had time to come up with the answers to such specific questions, because today we can't even find the answer to a more general question—what, in general, is our space-based science program like?

(To be continued)

[17 Dec 91 p 3]

Part Four

World statistics show that all the "space" powers are continuing to expand their outer space programs and to increase the appropriations for them. In our country, the "caravans of rockets"—beautiful words from the favorite song of Yuriy Gagarin—have stopped at dried-up financial wells: appropriations for space dropped by roughly 10 percent and were, in 1990, some 12.4 billion rubles (R), as compared with $10.9 billion in the United States. Based on recent exchange rates, our country is spending roughly 100 times less (!) on space research than is the United States. According to foreign data—precise data is not published in our country—as much as 75 percent of that money goes to defense projects in our country. Other figures sometimes appear. For example, in 1989, we spent R1.7 billion on space science. Why 1.7, and not 0.7 or 3.7? The answer, which seems very logical, is this: because that's the very sum that is needed to execute the Soviet science program for space research. But that answer is false. We don't even have such a program!

That may seem like some sort of nonscience fiction, but it's exactly how things are. And there hasn't been such a program for several years now! The Interdepartmental Scientific-Technical Council for Space Research is headed by the president of the Academy of Sciences, Guriy Marchuk. The multifacetedness of his scientific interests is so great that the polyhedron is virtually degenerating into a smooth sphere of theoretical indifference, which is particularly noticeable with regard to the space program. In 1988, Marchuk chaired a meeting of the presidium of the Academy of Sciences that discussed a draft of the science-oriented space program. At the meeting, Marchuk voiced the opinion that our country "is among the leaders" in space research. What that meant, no one knew. Either you're the leader, or you're not the leader. There's no such thing as being "approximately first." That's how the president disguised the fact that our country has lost preeminence in the world in space.

Two reports were given at the meeting. Academy astronomer Aleksandr Boyarchuk spoke of the successes of astronomers working in ground-based observatories. Unquestionably, there were successes, but they had absolutely nothing to do with space research. In the wake of that report, Academician Roald Sagdeyev, who was still the director of the Space Research Institute at the time, spoke of the victories achieved in extraatmospheric astronomy. With fervor, Sagdeyev sought to persuade those in attendance that the main part of our space program should be devoted to "an in-depth study of Mars"—obviously, the theoretical base was underpinned by launches of the two Foboses.

The study of Mars is something we need to do. But it's not *the* space program, just one of the branches of the space program. Mars is romantic and beautiful, but Mars can't replace the Moon, or the other planets, or biology and space medicine, or the very alarming global ecology problems. It can't replace technological, physical, or chemical research in the world of weightlessness or the enormous number of applied problems in remote sensing of the Earth. Sagdeyev didn't talk about any of that. His report evoked a rather lively discussion, out of which it became clear that "an in-depth study of Mars" is not a space program for a great space power. That didn't put off Marchuk, who announced that the presidium was approving that program and that it merely needed to be modified in accordance with the desires that were expressed.

The echo of that discussion bounced around the pages of our press for a long time. Here, for example is what the scientists said.

The director of the Institute of Geochemistry and Analytical Chemistry, Academician V. Barsukov: "For the first time in the entire history of this country's research, we, in 1990, have not had an approved program for two years already...We are replacing decision making that is carefully thought out and answerable to science with endless discussions and semantics...Instead of sorting out and approving a State Scientific-Technical Program of Space Research for the period up to the year 2005, the Academy of Sciences is creating a program solely for the study of Mars...."

Academician R. Sagdeyev (as of August 1989, Sagdeyev was no longer director of the institute, and the Foboses had already gone their own way—that is, Roald Zinurovich was at that point a personage with no responsibility for anything): "In any serious terms, we have no strategic policy for the exploration of space."

Dr Tech Sci K. Feoktistov: "I am convinced that we have no strategic policy and haven't had one, even though we can't do anything without plans or programs."

Cand Jur Sci V. Postyshev, member of the International Institute of Space Law: "People are getting the impression that the USSR does not have a unified concept for the exploration of outer space.... No one knows who bears the responsibility for realizing a given space project or cancelling it."

Nobody bears that responsibility! If people die, the person responsible is found. So, why do we need a program? In 1989, a total of 102 launch vehicles lifted off, and 136 satellites and two interplanetary probes were put into orbit, as was one manned craft. In 1990, a total of 75 launch vehicles went up, as did three manned vehicles and six Glonass satellites—for a global navigation system. (It doesn't matter that of 39 of our Glonass satellites, only four were in operation as of the beginning of 1990—we need to launch more.) And there were three new navigation satellites for the old Tsikada system, and a new satellite, Nadezhda, for the international emergency system Cospas. (Again, it doesn't matter that of the five of our rescue satellites, not one has saved or could save even one of our airline passengers, because our airplanes aren't equipped with the emergency radio beacons. But that's small stuff. What's important is that the satellites are aloft, and the whole world is aware of our noble initiatives.) And satellites for optical and various types of electronic surveillance number in the dozens. And all that without any state-wide plans or programs! And—I say this with the data to back it up—that scandalous fact is known to all levels of authority. We don't have a program, but thousands (!) of industrial enterprises are fulfilling orders for rocket hardware and the space industry. How that can happen is beyond human understanding.

People might retort: "What do you mean, we don't have a program? We have one! Scientists have gotten together and have decided that studying Mars is of the greatest interest, that we shouldn't spread our money out, we should focus it. We'll do one job, but a very valuable one. What's so bad about that?"

What's bad, I would answer, is that no one has proven that Mars today is what we need the most. Nobody has proven the soundness of that decision in terms of science, or industrial base, or economics. What's bad, I would add, is that I and many other people better informed than me have no faith that that voluntaristic, albeit interesting, program will be completed. Back in 1987, when the 30-year anniversary of the first satellite was being celebrated in Moscow, it was announced that in 1994 we would send to Mars an interplanetary probe that would make a detailed photographic survey of that planet, i.e., refine (or repeat?) what had been done 20 years ago by the American Mariner 9 probe and 15 years ago by the Viking probe. Then our probe is to acquire data on the chemical and mineral composition of the Martian surface and on the temperature distribution, which was also done by Viking. Then our probe is to release research and television gear. But Viking already showed Earth a Martian panorama back in 1976!

Again, some might retort: "The Soviet research will refine the American research and add to it, and even if it were to repeat the research, that would give it greater credibility."

Nothing of the sort will happen. Our gear is no better than what the Americans had 15 years ago. In the summer of 1972, four years before the Americans, we made the first soft landing on Mars with the unmanned Mars-3 probe, but it wasn't able to show us anything. Its main achievement was that it delivered pennants bearing the Soviet Union insignia to the Red Planet. But the problem is not even with gear. We're not going to be able to launch a probe in 1994, and, it seems, that's already clear to everybody. After announcing the launch date in 1987, we did virtually no work whatsoever on the vehicle until the end of 1989, although a competition did select the instruments for hefty sums of hard currency. Interest in the Mars program sagged after the Fobos failures. In 1990, no money was allotted for that program. People stopped writing about it, and survey articles about space didn't even mention it. Nevertheless, in late November of that year, everyone again gathered, to confer with foreign colleagues (a special, warm friendship had already formed: sometimes they would come to confer with us, and sometimes we would go to confer with them, which was even better, because it was more nourishing). Again we discussed the program and the instruments. And the new RSFSR minister of science and technical policy, Boris Saltykov, assured everyone that the government of Russia would do whatever was necessary to have the flight to Mars take place right on schedule. God is with us. But wait, Vladimir Bulgak had been appointed minister of communications, information science, and space in July 1990. So why is Saltykov concerning himself with the Mars program? It turns out that Bulgak's job by now has been "cut back" to just the one "communications." It's nothing but a puppet theater.

I'd like to note that since our system itself limits its leaders and forces them to look after the fate of only what they're in charge of, communications among chiefs, chief designers, and general designers are often unstable. That, and the absence of clear planning, results in the preparation of all scientific experiments in space taking place, without exception, in a very rushed environment. We're always hurrying and always being late. That can't help but affect the quality of the gear and the techniques used and, consequently, the number and quality of the results we get. We tried to get in a hurry even with the study of Halley's Comet, even though our grandfathers knew well before that Great October when it would be arriving.

The first director of the Space Research Institute, G. I. Petrov, complained to me that he had suggested direct radio transillumination of the core of the comet, which

would have enabled accurate determination of its density. Petrov is very interested in solving the mystery of the Tungussk meteorite, and the data on the comet's density would be helpful to him here, on Earth. A Space Research Institute preprint on the subject was published, but the academician's idea wasn't even discussed in his home institute, and nobody had time for him, and the instrument wasn't installed on the probe. Halley's Comet visits us once every 76 years, and that, to some extent, may explain the hurry: "Well, if we miss it, what are we supposed to do—wait another 76 years?" But why are we always rushing around when it comes to the Moon, Mars, or Venus, when a launch may have to be moved not decades, but only days or, at worst, several years.

As you get closer to the heart of the problem, you see that there is actually someone who sets up our plans and the program. That working organ, created by M. V. Keldysh and S. P. Korolev, has in its past many years of experience involving very fruitful work. I'm speaking of the Interdepartmental Council for Space Research (MNTS KI). It's job is to decide what needs to be done and to map out all the programs. After bringing all the programs together, it checks to see which points of the programs overlap, and it determines who gets what money from the budget and who will be invited to be coauthors from which plants and NPOs, and, if required, it determines where abroad to place orders for production and sets precise deadlines for implementing all the points of the adopted programs.

It's clear to everyone that the scientists should have priority. Today they don't have that priority and can't have it, because they're not united by common goals or interests—each one is "hogging the blanket." Physicist K. Gringauz is concerned about a cutback in the number of satellites for research in near-Earth space. Astrophysicist R. Syunyayev is worried about high-energy astrophysics. Geophysicist V. Barsukov doesn't want to wait for a 1994 flight to Mars and demands that it be launched in 1992. B. Chertok, a specialist in automatic equipment and control systems, understands that work has to be found quickly for the Energiya super rocket and, in trying to save the prestige of the firm to which he has given 46 of the best years of his life, is fighting for the giant communications satellite that would solve all the television, telegraph, and telephone problems in our country. (Boris Yevseyevich's proposal seems to me to be quite worthy of consideration.) And they're all probably right, but none of them can give up any of his own private problems, departmental obligations, collegial attachments, or nomenclatural preferences. None of them can "rise above" the whole of this gigantic system—the Soviet space empire that exists within the union of independent states. None can rise above and ponder the paths to progress for the entire space program in the foreseeable future.

When he came to the Soviet Union, the Nobel laureate Professor Leontyev was asked what our country lacked most.

"Strong personalities," he answered.

President Guriy Marchuk is not, unfortunately, President Mstislav Keldysh, whose energy and authority actually put us in the lead—not "among the leaders"—in world space activity in the late 1960s and early 1970s. General Designer Yuriy Semenov is 56 years old. His great predecessor Sergey Korolev was younger when he put together the grandiose plan for the exploration of space that we adhered to for many years after his death. I knew Korolev, and I can't imagine him allowing a situation like the one in which this country has lived now for several years, with no science program for the exploration of space. And he wouldn't accept any excuses of collapse and ruin, believe me.

But Korolev isn't around any longer, and I don't think any such individual will appear soon: nature is thrifty when it comes to that kind of person.

But "a sacred place doesn't stay empty long." Once the Interdepartmental Council demonstrates complete scientific impotence, all kinds of replacements can be found that, more often than not, are less powerful, but are considerably more adept at concealing it. In late October 1990, the CPSU Central Committee Commission for Science, Education, and Culture was set up. The 35 commission members included 11 party apparatchiks, more often than not first secretaries of obkoms (as everyone knows, those are the most prominent leaders in science, education, and culture), and, for some reason, one electric welder from Kharkov. In his best king's speech, the chairman of the commission, Academician Ivan Frolov, said: "It's time we bade farewell to our scornful attitude toward apparatchiks. In performing difficult coordination and organizational work that often goes unnoticed from the sidelines but is very important, they have become the targets of attacks, often unfair." (How unfair those attacks are, we have already seen from everything that was said above.) The first of the named tasks that the new commission performed was this: "develop conceptual principles for the optimal use and further development of the intellectual potential of the country and for the top-priority development of science...." God is gracious: the commission had no time for "intellectual potential" or "top-priority development." Just like the CPSU Central Committee as a whole.

But all kinds of "saviors of the Fatherland" are constantly appearing. Here's a quite recent document: "Order of the Presidium of the USSR Academy of Sciences" from 3 October of this year, on the creation of a consulting council "Space-Earth," signed by the president of the Academy of Sciences. After reading the order, I had no idea what the council was created for. To take some work off the shoulders of G. Marchuk and give it to the MNTS KI? Or to come up with the new position of "Consulting council coordinator" for Dr Tech Sci V. Shvarev? I couldn't find any other explanations for the

existence of the new council: his work consists of knowingly duplicating the work done by other, existing organizations.

In a very direct way, the following organizations are involved in our space program and are deciding exactly which direction we'll be flying in: MNTS KI, the Space Research Institute itself, the Ministry of Defense, the Central Scientific Research Institute of Machine Building (the head institute of the former Ministry of General Machine Building), the State Center Priroda of the State Committee for Geodesy, the NPO Planeta of the State Committee for Hydrometeorology, and the All-Union Scientific Research Center Ekologiya of the Ministry of Natural Resources [Minprirody]. It's like having seven nannies for one child (in fact, there are more than seven!). So let's remember the old Russian saying and not be surprised that the Deputy A. Neumyvakin, the chairman of the All-Union Society of the Blind, is the one who defended the appropriations for the space program at meetings of the Supreme Soviet before any scientists or cosmonauts did.

Enough of this rousing and unnerving of the readers, though. The program was and is, but it's as if it doesn't exist, because it has never been discussed anywhere publicly, has never been published, has never been voted on at any of the Supreme Soviet sessions, and, until recently, was purely a departmental, almost private, affair, inasmuch only a few people—primarily the heads of the space centers themselves—were able to change it, change the deadlines, insert anything, or emphasize anything, whenever something benefitted them. It's my understanding that not even the President of the country was among the "decision makers." In answering a question about who would be the first journalist to go into space, for example, he publicly announced this on the pages of PRAVDA: "The question has already been decided. The first journalist will be one of ours, and he will go up before the Japanese journalist." But those who "put together" our programs didn't listen to that, and the first journalist to go aloft was a Japanese.

Until very recently, the final decisions in matters of the development of our space program came out of the interior of the military-industrial complex, or to be more precise, out of the offices of the Ministry of General Machine Building.

The head of Glavkosmos, Aleksandr Dunayev, admits this: "The main tenets of the all-academy program 'Issledovaniya kosmosa' [Space Research] (*obviously, he is speaking of the notorious Mars—Yaroslav Golovanov*) have been coordinated with Glavkosmos (*which is simply a subdivision of the Ministry of General Machine Building*) and the 'Program for the Creation of Space Hardware for Science and Scientific-Economic Applications for the Period Up to the Year 2005,' which was developed by the USSR Ministry of General Machine Building." Working in Glavkosmos, I must remind you, are beginning businessmen. The ministry has been directing the plants. Thus, everything is upside-down: the scientists don't set the objectives for the manufacturers of instruments and equipment; rather the ministry, with its contractor-manufacturers, decides what the scientist-customers need. "You need a hat? Well, you'll get a cap. And if you don't take it, you'll walk around with your head uncovered." That's the formula for their relationship.

I'd like to see the faces of NASA officials if, for example, the president of Lockheed announced that his company didn't think it would make the Hubble telescope, but might rivet together an all-terrain vehicle for Mars instead. But now, God willing, everything will get right with our space program: after all, the Ministry of General Machine Building has been dismantled. And Minister Oleg Shishkin is no longer a minister. Elected by the directors of the enterprises that made up his ministry, he is the president of a special corporation. "Most probably, they saw me as a specialist. After all, I was involved in the development of the Energiya-Buran project," Oleg Nikolayevich modestly comments on the results of the election.

All they did was change the sign out front.

When you're thought of as a complete idiot, you get a very unpleasant feeling that's like some sort of internal itch...

(To be continued)

[18 Dec 91 p 3]

Part Five

It was roughly 1959, just two years after the triumph of the first satellite, that people began to say that space was not profitable, that it was dooming the people to beggary, and that it was basically time to close that office down. Then, when N. S. Khrushchev made the space program a powerful lever of his foreign policy and his internal ideology, they quieted down some. When times became a little leaner, they started up again. Our space program is like the Jews: it's to blame for everything bad that's happening around us. But those voices, especially loud and quite official, sounded out a new call from the rostrums of the USSR Supreme Soviet: "freeze" space!

Later, advice that was more moderate was heard: we don't need to freeze space, they said—we need to make it pay for itself: let them twist in the wind a little, and they'll begin to be a little more lively about expanding conversion.

Everything I wrote in the previous installments in IZVESTIYA was permeated with caustic criticism sent out in many directions. 'Things are bad everywhere' might seem to be the conclusion of this investigation.

But despite all my negativism, I am firmly against any kind of clamp down or freezing of research in space. Making the space program pay for itself is economic nonsense. Lt Gen Avn Vladimir Shatalov says that in 1990, from the one flight of the Japanese [journalist] we

got as much money as was allotted the cosmonauts for all of 1991. Does that mean that after the flight of the Englishwomen and the flight of the Austrian, we're way in the black? In not one single country does a space program pay for itself, and ours couldn't, even if we were to become a lowly space "carrier" who didn't give much of anything to science or technology, much less national prestige, but merely gratified the vanity and advertising ambitions of customers. The space program should provide us knowledge, technology, materials, and information in the broadest spectrum. Those things are valuable, and in no small way. We have to pay for them. That's why an unsubsidized space program is a fiction and a myth that we've got to part with once and for all.

"How can you say that?" some would retort. "Look at how much the space program gives our national economy!"

That's a very difficult issue to deal with, because no one knows what that figure is, and there exists quite a sound hypothesis that says that that figure is negligible.

Look at how much has been written about the work done on the Mir orbital station, for example! But did you know that Mir's orbit, because of requirements for radiation safety, has a low inclination, which enables the cosmonauts to view only about 20 percent of the former USSR? Even if we were to incline the orbit at 65°, a third of our country still couldn't be seen. Round-the-clock observations can't be made, and the best observations are possible on only a small portion of each orbit.

The whole secret of the attractiveness of the numerous florid articles on the Space-Earth subject is that they give examples not of what is being used or has been implemented, but of what could be used and implemented. But then the question resounds, But what is hindering that use?

I discussed that topic with many people—the chairman of the State Committee for Environmental Protection, Nikolay Vorontsov, for example; his deputy, Aleksandr Bazykin; and the first deputy director of the Main Administration for Environmental Protection Information Systems, Viktor Kutsenko. Do they need space-derived information? Yes, very much so! *Very* much so! And they need all kinds of information! But you have to pay for the information you get, and they don't have anything to pay for it with—there's no money!

"The defense people are generous people," they told me. "They allotted more than 24 million rubles (R) for ecology, but none of it ever got to us. We didn't get even 1 percent of all the money that was released for saving the Aral Sea. We're too poor to outfit the orbital station with our own equipment..."

Vorontsov showed me a large color image. It was the Kuznetskiy Rayon of Moscow. Clearly visible were the smoking dumps and the turgid flows into the reservoirs, and red threads of heat losses surrounded the residential buildings.

"This was given to me by Pavel Popovich because I'm a deputy from the Kuznetskiy Rayon," says Nikolay Nikolayevich. "But we don't have the kind of money it takes to buy such images...."

We're at the Okean Center. Here's the head of the department for the development of techniques and equipment for remote observations of fisheries, Yuriy Zonov:

"Only the Meteor satellite can provide fishermen with daily information on the weather. We gather fishery information and send it to the fishermen once a week. The Okean satellite (it's actually Kosmos-1500, which in all our articles we call so proudly the "fisherman's satellite"!) gives us virtually nothing, because its orbits are such that it sees fishery regions that are of interest to us only once every 10 days. And if there's a wind, you can't make anything out...."

The chief of the Scientific-Technical Administration of the USSR Ministry of the Fishing Industry, Sergey Dyagilev, says this:

"Let's talk frankly: there is no satellite for fishermen. The Okean provides a very rough location of schools of fish, measured from space not in minutes of arc, as we need it, but in degrees. What we need is a satellite with gear that is capable of pinpointing schools of fish and productive plankton areas and of promptly throwing that information down if not to our ships, then to our receiving centers in Murmansk, Kaliningrad, Vladivostok, Sevastopol, and Moscow. Three years ago, we didn't have to pay the "space people" anything, because we got everything free of charge. Now we have to pay. But doesn't it seem logical that what we have to pay should depend on how much we catch?"

It certainly does! The fishermen should pay the space program for fish, the farmers should pay for harvest forecasts based on harvest prices, and the geologists should pay for a tipped-off deposit based on its yield and how easy it is to work. That's exactly how I think the relationship between the national economy and the space program should be structured in the context of the market.

A different argument, which also requires critical analysis, is also cited in defense of the space program.

"Moreover," they tell us, "look at how much we will learn in space. And then the work itself that involves space facilities and is performed here on Earth will create new technologies and materials and will raise the standard of labor. In short, it improves our lives here on Earth. Did you know, for example, that while working on the Energiya-Buran system, specialists created 581 variations of new materials? The names alone of the materials and the various units and assemblies of Buran, declassified and intended for use here on the ground, take up three fat tomes!"

It's that same old story: wishful thinking instead of reality.

"I don't know of one ruble that's been received for, say, the transfer of technology from that very Buran to the national economy," says Konstantin Feoktistov, cosmonaut and doctor of technical sciences.

Boris Olesyuk, from the Flight Control Center, says that not one thing has been transferred, and no one is even taking anything for free.

And again the question, Well, then, just what is preventing us from crossing the space program with the ground-based economy and producing a remarkably fruitful hybrid?

First and foremost is this: the conservatism of the very system that created the word "vnedreniye" [transfer], which isn't even in the prerevolutionary dictionaries. The second thing is objective: the absence of the equipment and raw-materials base that are available to the enterprises of the military-industrial complex, but not to those who could use the technologies and the things that have been developed by those enterprises. The third is this: the secrecy is so rigid that it can change any new technology at the moment of its "transfer" into an obsolete technology. Every country has secrecy, but only in our country does it curtail state revenues instead of increasing them. The fourth thing is this: the need to retrain personnel, replace equipment, etc., which promises a slow-down of existing production. Such, in my view, are the things keeping the space program from helping the national economy and, consequently, from strengthening its own social authority, from convincing people of its economic capabilities, from proving its usefulness.

Now about conversion, in which the rocket-and-space enterprises themselves are changing over to "ground" production. Everyone welcomes the idea of conversion on paper, but when it comes to actually doing it, there is a sometimes clear, more often than not secret, but wholly explicable and, from my point of view, justified resistance to conversion.

People who yesterday were making atomic bombs, rockets, and advanced fighter planes do not want to be making chamber pots, kitchen appliances, or baby carriages, because they lose their salaries, their ratings, their sense of professional worth, and the pride they have in their "firm." In addition, everybody forgets that conversion takes some big spending, because a warhead with a handle welded on the side—it's not a chamber pot. Order will have come to our country when everybody is working in his profession: when the "bomb-makers" (as L. I. Brezhnev called them) will be making nuclear reactors that are as reliable as their bombs and will be bringing us closer to an understanding of controlled thermonuclear fusion; when the aircraft designers are building airplanes—not fighters, but passenger planes, and lots of them, so that people don't live in airports for weeks at a time; and when the rocket-makers are making rockets. But why do we need rockets?

If our space program can't pay for itself inside the country, then it could make a pretty good living in the outside market. It could, but it won't. And here again, we must blame, above all, our system of secrecy: when we're ahead, we can't talk about anything, because our "enemy" might catch up with us; when we're behind, we can't talk about anything, because we don't want him to find out about it. It wasn't until 1985 that the "legal" offshoot of the "closed" Ministry of General Machine Building—Glavkosmos—was set up. Its first commercial success reminds one of the business that kids have cleaning windshields while cars are stopped at traffic lights: $7.5 million for the launch of the Indian IRS-1A satellite in March of 1988. OK, the first step is the hardest. But soon it turned out that a real misfortune occurred: we had slept through the alarm for the outside aerospace market. Sure, there are objective reasons that we use today to excuse ourselves: COCOM forbade the export of advanced technologies to the USSR. We aren't allowed to launch a rocket if it has even one American part or if it uses U.S. technology in its application. And an agreement with Space Commerce Corporation for the launch of an American satellite atop a Soviet rocket was already signed. But it didn't take place.

We and our partners suffer because of all that. After all, if our Proton rocket charges $35 million for putting a 2.2-ton cargo into stationary orbit, the American Delta 2 charges $50 million for 1.5-1.8 tons.

Yes, there are objective reasons for our not being able to earn money, but they're outnumbered by subjective reasons. We do not understand the business conditions of the foreign market very well. We concluded a contract with the Japanese firm Pax Corporation, and in terms of certain points, the contract was unfinished, and it was signed without our trade representative specialists, and we advertised the firm all around. And then the firm went bankrupt, and now we have to file suit for $6 million, and we don't even know how to go to court over there. Why did we get $12-15 million (the exact figure is a trade secret) for taking a Japanese journalist aloft, when the Americans would have gotten $35 million? When Toyohiro Akiyama himself was asked about that, he answered in English, in a tone that makes me burn with shame: "You really don't see? They need the money."

It's an absolute mystery to me the soup we got ourselves into after we sent the Englishwomen Helen Sharman up into space. I mean, we were ready to collect $15 million, but we only got $5 million—that was just for training two Englishmen in Zvezdnyy Gorodok. But what about the money for the flight? For the use of the equipment in orbit? Or was it like before—we thought that now England would love us amd would send us sausages for free? I don't know of a single well-thought-out space-program action that we've performed on the outside commercial market. Our being a space "carrier," which

is feeding the Cosmonaut Training Center, is only reinforcing the suspicion that Glavkosmos is impotent. Last year, the Chinese rocket Chang Zheng 3 broke into the world market and put an American satellite into orbit. Why hasn't ours? The Chinese were allowed to launch nine American satellites three years ago if they kept the launch fees in the mid-range of world prices. They didn't stick to the agreement, but on the first launch, they earned $30 million—much more than our entire annual space budget. The Japanese are selling the Americans engines for space rockets. And why are we not selling? All our attempts today to put our outside space business in order should be encouraged in every possible way and should be welcomed.

No matter what political and economic forms what we used to call the Soviet Union is remelted into, we will remain the great world power that opened the space age. Yes, in recent years, in my opinion, many mistakes have been made and there has been some outright bungling. But does anyone really think that it's just been in the space program? We speak of the "new thinking" in politics. We also need some new thinking in the space program.

We say that we've got to relearn economics. Basically, we need to relearn how to live. The space program needs a radical reorganization. A business involving billions and billions can't be managed so inefficiently, so chaotically, in such an uncoordinated fashion, never professing in the process any general idea that consolidates socioeconomic and scientific-technical interests in the formulation, analysis, approval, and embodiment of all programs and projects. The space program needs a boss—an intelligent, educated (those are not the same thing!) individual who has been given the authority to make decisions and finance them and who is capable of justifying those decisions in a well-reasoned fashion, apart from all departmental interests, and of explaining them to the public.

Breaking is not building. If we destroy and financially strangle the space program, we will destroy one of the major areas of modern progress and one of the very few areas in which we have dignity and prestige in the world community. The calls to curtail the financing of the space program are calls against the state. We again risk showing the entire world our narrow-mindedness and our firmly entrenched habit of building our lives on the basis merely of concerns for the moment, without a thought for tomorrow. There is already much for which posterity will not forgive us. And it might also not forgive us for destroying the space program.

Events at Baykonur Cosmodrome During Coup Attempt

917Q0185 Moscow PRAVDA in Russian 14 Sep 91 p 3

[Article by test engineer Yuriy Markov: "How It Was at Baykonur"; first paragraph is PRAVDA introduction]

[Text] **Did you know, when sprinkling your pilaf with Indian pepper, washing it down with Indian tea, and in the meantime looking at the screen of a Japanese Toshiba television, which was delivered from India, that this is the payment of the Indian side for the IRS-1A satellite, which was launched three years ago by a Soviet Vostok launch vehicle? Now, very likely, there will be even more tea, because at the end of last August the Indian IRS-1B satellite was launched from the Baykonur cosmodrome and began to probe successfully the surface of earth. The days of its preparation and launch turned out to be hot—not just in the climatic sense. The notes of the test engineer of space hardware are about that.**

Notes of a Tester

...One after the other, blunt-nosed trucks drive up to the IL-76 airliner. From its enormous belly they remove crate after crate. The job is not easy. The temperature is nearly 40 degrees, and there is a strong searing wind. Salt comes out on cracked lips.

All these instructions somehow resemble the famous souvenir—the Russian matryoshka doll. To get to the satellite, it is necessary first to open our container and get the Indian one, then open the "cylinder," and then remove the snow-white protective covering, and only then will the fine golden cube-shaped satellite appear before you. But that won't happen for two days, in the hall of the technical complex. But while the satellite is taking the first steps on the land of Baykonur, the column has been setting out.

For the present I cannot say exactly how the fate of the second satellite will turn out, but I know that its completion at the cosmodrome will be difficult for Soviet specialists. Why? Many troubles have befallen the cosmodrome. The most serious situation is with water. There are heaps of work to be done before a new water line can be put into operation, and besides, deliveries are being disrupted. The old line, which was laid 35 years ago, is continuously breaking down: pipes burst, worn-out pumps break. Roads, services, and structures are "crumbling." The frequent and unpredictable whims of the power transmission lines make one shudder. The cosmodrome nears a considerable amount of money fast to maintain a normal life for the people and the efficiency of equipment. But who will provide it....

But what about earning it? Our domestic industry has a wide range of launch vehicles of every possible class: the Vostok, Molniya, Soyuz, Tsiklon, the extremely reliable Proton, the now-under-development Zenit, and, finally, the powerful Energiya. We can ensure the launch of practically any payload. But first money just has to be invested into the infrastructure of the cosmodrome, in order to attract wealthy clients, including from developed countries, in order to enter the world market of space services....

...Two launch vehicles—a Soyuz for the Progress and a Vostok for the IRS—came to the cosmodrome on the same train. Oh, what a hard time the rocket specialists

will have! The wave of reductions has already reached the cosmodrome. And now it will be practically just one crew that will have to prepare two rockets simultaneously (the Progress is lifting off on 21 August, the IRS on 29 August), and at work sites that are a good 35 km from each other. And both launches are extremely important: the Progress is going to the manned Mir station in order to resuply stocks that have been used up, without which the crew cannot exist, and the IRS is the most important national space program of India.

Sunday—18 August—was a very intense day of work: the standard charging of the batteries was completed, and the spacecraft was prepared for fueling, transferred to the transporter, and transported by rail to the fueling station. They didn't finish the work until late that night. But on 19 August, at 0830, all the chiefs of the services and representatives of the military units were at the traditional morning planning meeting. For some reason, the permanent head of strategy meetings, our test director Nikolay Alekseyevich Korolev, a "lark" by nature, who is always punctual and is first to arrive at meetings, was delayed. Finally he entered, looking drawn and dark. He took the chairman's seat.

"I just heard on the radio. There has been a coup. Gorbachev has been removed from power. A State Emergency Committee—Yanayev, Kryuchkov, our former minister Baklanov, Pugo, Yazov, and others—has taken power."

Dead silence. Korolev, catching his breath, added:

"In my opinion, this is the darkest day in the history of the country."

I became afraid for him: after all, among the 30-40 specialists in that room, there were very likely the proper "comrades" who would immediately report that, who would let "the proper quarter" know....

But Korolev would not be Korolev if he did not joke (although very somberly): "So, what, I guess they'll shoot some of us very soon. Isn't that the truth, my friends?"

And after the reign of another silence, he announced:

"So, the jobs for today...."

But nobody listened to him very well. Everyone was brooding, in a gloomy stupor. However, the tragic is always interwoven with the comic.

Aleksey Sizov, who was late, enters and flops into the next chair, and whispers in my ear:

"A catastrophe.... It is the end for all of us!"

"Is that how you assess the situation?"

"But of course! Some 150 cubic meters sank into the sand! (An accident had occurred that night at the refrigeration center, and without cold water it is impossible to ensure the proper temperature-humidity conditions of the tests for the satellite.)"

"I thought you were talking about something else...."

"What?" he leaps.

"About the coup d'etat...."

"?!" Aleksey clutches his head.

On the little square near the dining room there are small groups of people who have eaten. From wireless telegraph they are learning of the tanks on the streets of Moscow, the cancellation of leaves from the army, the stepped-up patrolling in the city of the cosmodrome: the order has been given to arrest anyone who is attempting to organize meetings or post leaflets and to immediately take them the commandant's office.

The first two days, from my observations, society was split into three groups. A tiny few of the orthodox people I know welcomed the coup unconditionally: "I am sick of the chaos. Let's establish some order!" We all know what order is to them. Another group—also small—endorsed the removal of Gorbachev, but felt offended for Yeltsin: "Him, don't touch! He is the head, the first ever elected by all the people. And no one has the right to interfere with his reforms."

But the absolute (I hate the word "overwhelming") majority uncompromisingly condemned the anticonstitutional coup: "It's the people who should decide whether the President is good or bad. Without freedom there won't be any bread!" Not one single person believed the President was sick. And a leadership that begins with a lie is, sooner or later, doomed.

The young people were amazing. I looked in once, morose, at the teletype. The young people from Moscow, Lena and Kolya, say in unison: "This junta will not last more than a week."

Practically all the residents of the cosmodrome are subscribers to KOMSOMOLKA [KOMSOMOLSKAYA PRAVDA]. Upon learning of its closing by the putschists, many openly expressed their sympathy to me, a writer on it for many years. But there were also such people who stopped saying hello.

...On the night of the 20th-21st, Reddi Anantaram and I went to look at the night launch of the Soyuz launch vehicle with the Progress on board. It is about four in the morning local time, a starry night. The rocket goes up and there, high up, is lit up by the rays of the sun. The sight has a deep effect on Reddi. He stands with two thumbs up.

...Ballistic experts Yuriy Bozhor and Aleksey Ryazanov flew in and brought leaflets bearing Yeltsin's appeal, and "underground" newspapers. For two nights, the 19th-20th and the 20th-21st, Aleksey had stood in defense of the "White House," working during the day, and on the 22nd he took off for Baykonur. Bozhor also spent several hours at the barricades. They told us that dozens—if not hundreds—of people from our firm had been were in the "living rings" of Muscovites night and day. And our

firm, the Scientific Production Association imeni S.A. Lavochkin, is considered one of the pillars of that very complex.

At the cosmodrome the Indian specialists sympathized with us and, while tactfully not interfering in our internal affairs, still unanimously desired the defeat of the reaction. On the 22nd, we watched the rally of the victors on the Square of Free Russia. I had never seen such fine people in all my life. I must say, we testers, far from sentimental people, could not keep back the tears. That day the "dry law" was seriously violated. We raised glasses with spirits to the Muscovite heroes, who had scorned slavery and fear. An officer went to the city with the text of our joyful telegram.

I still remember the speech in the State Commission by Kira Belostotskaya, a prominent specialist in space radio communications, who told how the putsch nearly disrupted the preparations of the Flight Control Center, which is in suburban Moscow Medvezhiye Ozera. First their car, in which there were also Indian specialists, was nearly run over by tanks that were going to Moscow, and then the curfew disturbed the work schedule. "I burned with shame," she said, "that in the late 20th century there are rulers who send armadas of tanks against their own, unarmed people."

...29 August 1991. A bright, hot, sunny day. In the sky there is not one little cloud. At 11:48:43.187 Baykonur time, the Vostok launch vehicle with the Indian IRS-1B satellite, to the stormy applause of the Indian specialists, lifts off from Earth....

Zenit Launch Failures Ascribed to Policy of Conversion at NPO Yuzhnoye

927Q0013 Moscow EKONOMIKA I ZHIZN in Russian No 42, Oct 91 p 11

[Article by M. Arkhipov, senior officer of press corps for space units, USSR Ministry of Defense, under the rubric "Problems of Conversion": Where Did 'Zenit' Run Off To?"]

[Text] For almost 30 what people call today "stagnant" years, our country was considered a leading space power. Several types of launch vehicles of various classes were capable of launching from three Soviet cosmodromes cargoes that weighed anywhere from one and a half tons to 100 tons or more. Western experts gave high marks to them for their reliability, which varied from 92.4 percent for the Protons to 98.9 percent for the Vostoks.

In the mid-1970s, development got under way of a unique, new-generation launcher. Ecologically clean, capable at a launch weight of 459 tons of putting a satellite weighing 16 tons into orbit—and later of putting heavier cargoes aloft—it immediately attracted the attention of the world space community. The Zenit was developed by the NPO [Scientific Production Association] Yuzhnoye.

Unfailing fulfillment of the state order, plus the wages that, high for that time, were earned by the Ministry of General Machine Building's blue- and white-collar workers who were involved in space production, made it possible to put the launch vehicle into series production and ready the launch complex via a completely new system—the "peopleless launch," which precluded fatalities in the event of an accident.

Fourteen successful launches of the new launcher were assessed by Western experts as demonstrating 100 percent reliability. Moreover, the first stage of Zenit passes certification as the four units that serves as the first stage of the Energiya rocket. Those and other features setting the Zenit off favorably against the similar-in-class American Titan and the French Ariane singled it out as one of the most probable launchers for the International Space Launch Facility being created in Australia.

The last Zenits that were manufactured before perestroyka were launched, and when the launchers that were manufactured in the "new time" were stood up on the launch pads, the first failures began. Minor failures, they were written off to flight tests that called for subsequent finishing and modification of individual systems.

Last year's launch-vehicle accident, which destroyed the launcher and damaged the expensive launch complex, resounded like thunder in a clear sky. The cause of the unsuccessful, fifteenth launch was studied by an expert interdepartmental commission that reached a conclusion after several months of work: "...the cause of the destruction of the RD-170 engine of the rocket's first stage was organic compounds that had gotten into it during the assembly stage after hot firing tests."

The prestige that Zenit enjoyed in space circles in the West could be restored only by a successful launch. Space specialists around the world understand that ensuring against failures is difficult, and besides, the opinion of the commission asserted that what had happened was quite by chance. There was a broad range of possible reasons explaining how organic material got into the engine.

The specialists of the USSR Ministry of Defense's space units, together with representatives of the NPO Yuzhnoye, began to prepare for the sixteenth launch, which was scheduled for the end of July. But alas, it was not meant to be. The launch, held up within fractions of a second because an engine of the first stage didn't start, demonstrated the high degree of reliability of the emergency decision-making in the course of the final launch operations with Zenit, on the one hand, but revealed a malfunction in the ground equipment of the launch complex, on the other. An improperly made arm for the erector of the launch vehicle was off by a few millimeters after returning to its place. The disassembly took a month.

And then on 30 August, Zenit again stood in its splendor on the launch pad. The complex's ground equipment worked without a hitch. The long-awaited launch time

arrived. As if reluctantly, Zenit separated from the launcher and rushed up to the heights beyond the clouds. The launch team breathed a sign of relief—it had performed its job irreproachably. The Central Television cameraman was happy about the good film he got. But it wasn't Zenit's lot to put the cargo into space orbit. Because in the third minute of the flight, at the point at which the sustainer engine of the second stage was supposed to start and go into working mode, the rocket malfunctioned. That's what the materials from the work of the commission say; for the uninitiated, that simply means it exploded.

So just what happened to that candidate for international citizenship this time? The commission names several causes related to possible infractions in the manufacture of the engine and in its storage, as well as in its delivery to the cosmodrome. Zenit, with engines manufactured in 1988, was already doomed at that time to failure. The reason—"conversion"?! How could it be otherwise, when the converted Yuzhnoye association changed over from steady series production of the Zenits to unit production. And the plant's production, started during conversion, of Mriya kitchen appliances, electric coffee grinders, and other electrical appliances so scarce in our time made it possible for those who assembled those appliances to make substantially higher wages than the wages made by the Zenit specialists. Experienced, highly skilled blue- and white-collar workers surrendered to even higher wages in cooperatives. Irregular production of Zenit, which instantly rose in price, came to be of lesser quality than that of series production.

Thus, conversion in fact not only deprived the international space market of highly reliable launch vehicles, but also failed to fill the domestic market with kitchen appliances. Mriya production is small scale and is inaccessible to broad segments of the population because of high arbitrary pricing. We have a paradox: in converting space production, but running to the world market in pursuit of hard currency, and not noticing that ourselves, we are sawing off the limb we are sitting on, failing to see that certain of the instruments and some of the equipment of the launch complex have already become obsolete today. Conversion curtailed their improvement, thinking them to be well enough along and reliable.

The second consecutive accident involving that unique launch vehicle brought the state millions more in losses and indicates that we're not dealing with a chain of fatal contingencies with Zenit, but a direct consequence of the conversion of space production, because the retooling itself of the space plants to the manufacture of consumer goods has necessitated many additional millions, if not billions, in spending that has brought about a still bigger disproportion in our already unbalanced economic mechanism. What would be more beneficial? Stop financing an activity in which just yesterday we enjoyed an unquestioned preeminence, or improve space production, with subsequent delivery of its products to the world market and to internal markets, thereby making the space program a source of hard-currency income?

The concept of "conversion," in one dictionary published some 40 years ago, is explained as the "selling off of bonds and securities at a price below the nominal." Isn't something like that happening in our country with our space program?

[Boxed material]

On 4 October of last year, at a planned launch of the Zenit launch vehicle from the Baykonur Cosmodrome, the first-stage engine failed in the third second of flight. The rocket fell onto the launcher and blew up....

Use of SS-18 as Commercial Space Launch Vehicle Urged

PM1411122291 Moscow Central Television First Program Network in Russian 1900 GMT 10 Nov 91

[From the "TV Inform" newscast: Report by S. Yurakov and V. Rekut]

[Text] [Announcer] The stormy events in politics and the changes in the stores and booths have somehow fenced off from us one of the most important problems whose solution should have a marked effect on our prosperity. I have in mind conversion. There have been many reports on changes in the defense industry but unfortunately so far there have been no results except for secret plants brought to the point of paralyses by hasty decisions.

[Yurakov] Over $10 billion could be earned as early as the current decade on the world space services market. That is the belief of the country's leading economists. And our space rocket enterprises would be prepared to realize these opportunities. Recently the scientific public marked the jubilee of the founder of Soviet military rocket building, Academician Yangel, who celebrated his 80th birthday. Yangel and his successors created in the "Yuzhnoye" science and production association an enormous scientific and technical potential making it possible to create the most powerful combat rockets. In the past the state made enormous expenditures and it is time to return them. Hundreds of these rockets are becoming available as a result of the fulfillment of the strategic offensive arms limitation treaty. After all they could be successfully used for commercial space launches, which would yield up to $100 million each.

[S.N. Konyushkov, general designer and general director of the "Yuzhnoye" science and production association, identified by caption] For instance the SS-18 rockets are potentially fine space craft launchers and we would be prepared to embark on this within the framework of cooperation with the international community but unfortunately there are substantial restrictions from the COCOM committee.

[Yurakov] The coordination committee for the control of exports to the socialist countries, or COCOM, is impeding the import of satellites on the territory of the

former Soviet Union . Western countries are stating their sympathy with our economic troubles but nonetheless are not allowing us to earn hard currency. So in what spheres are our partners in the new thinking prepared to cooperate with us? Only the humiliating selling off of resources.

U.S.-Soviet Group's Alternative Mars Landing Project

917Q0187 Moscow PRAVDA in Russian 13 Sep 91 p 4

[Interview with Candidate of Technical Sciences Vladimir Kotin, staff member of the Scientific Production Association imeni S.A. Lavochkin, by Yu. Markov, under the rubric "An Unusual Angle": "Are We Flying to Mars?"; first paragraph is PRAVDA introduction]

[Text] **Candidate of Technical Sciences Vladimir Kotin, a young staff member of the Scientific Production Association imeni S.A. Lavochkin (our well-known aerospace firm), returned the other day from the United States.**

Markov: What was the aim of your two-month trip to America?

Kotin: At the invitation of Stanford University, several of our specialists, including me, took part as independent experts in the formulation of an alternative project for a manned mission to Mars.

Markov: Alternative to what?

Kotin: An alternative to the project by NASA—a government organization. The fact is that within the framework of the so-called presidential initiative, which set the goal of landing Americans on Mars by 2019 (the 50th anniversary of the landing of Americans on the Moon), specialists of NASA formulated a grandiose program that calls for the deployment around Earth of large orbital stations (stage 1), then the establishment of permanent bases on the Moon (stage 2), and then, with the use of those bases, the preparation and dispatch of unmanned missions and, finally, manned missions to Mars (stage 3).

A group of scientists from a major private university, believing that the amount of money that [NASA] wants to take from the pockets of taxpayers is inordinately large and may drive many people away from the Mars program, decided to formulate an alternative project. It calls for lowering expenditures by nearly tenfold.

Markov: How?

Kotin: First, the Stanford specialists, who are headed by Prof. Bruce Lusignen, believe it necessary to "take the bull by the horns" right away, that is, deal with Mars from the very outset, bypassing the lengthy and complex near-Earth and lunar stages. They want to first use unmanned missions to deploy stations, Martian vehicles, and housing on Mars and then get the manned mission under way in 2012. Second, they want to use the Soviet Energiya launch vehicle, the most powerful in the world, which is capable of putting 80 tons of payload into the proper near-Earth orbit and whose launch they estimate at $300 million. Several launches of the Energiya will be required for the accomplishment of the program. That is why they called their program the following: "the American-Soviet Project of a Mission to Mars." Third, traditional types of rocket motors and freeze-dried foods are used on spacecraft, and only regeneration of fluid is employed.

Markov: But what's all that needed for anyway—developing those programs and flying to Mars?

Kotin: Man will always strive to open new horizons. And in general, the accomplishment of that task will raise all terrestrial technology to a qualitatively new level. And thanks to that, the expenses will sooner or later be recovered. The Americans understand that well.

Cooperation With U.S. on Mars Projects

LD0312125691 Moscow TASS in English 1256 GMT 3 Dec 91

[By TASS correspondent Vladimir Khrustov]

[Text] Moscow December 3 TASS—Next year the United States and the Soviet Union will carry out joint experimental sessions to receive telemetric data from the Voyager spacecraft and will create an Ussuriysk-Canberra-Goldstone radiointerferometric "triangle" in navigational support for Mars-Observer and Mars-94 projects.

Accords to this effect have been reached during a regular meeting of Soviet and U.S. experts on ground tracking and space telecommunications networks. The meeting took place in Moscow and Vladivostok.

The guests toured the long-range space communications complex at Ussuriysk—the RT-70 radio telescope with a mirror diameter of 70 meters, a spokesman for the Soviet Defence Ministry's space research subdivisions told TASS.

The radio telescope is operated by ministry subdivisions specialists together with the space instruments research and development association. A similar telescope has been built near Yevpatoriya.

The two countries' experts are expected to meet again in May 1992, two months after sessions of communication with the Voyager.

Leonov Involuntarily Retired as Deputy Chief of Cosmonaut Training

927Q0029A Moscow ARGUMENTY I FAKTY in Russian No 44, Nov 91 pp 6

[Article by V. Buldakov and R. Morozov, correspondents: "A. Leonov Retires"]

[Text] Despite the fact that today writings on the "space" theme are becoming less common in the press, the editorial offices frequently receive letters with requests for familiarizing readers with the life of cosmonauts.

In conformity to their wishes, our correspondents V. Buldakov and R. Morozov paid a visit to Zvezdnyy Gorodok.

This small city was built in the early 1960's. Now about 4000 persons live there, two-thirds of whom have virtually nothing to do with cosmonautics. At Zvezdnyy Gorodok there are but a few more than 50 cosmonauts. They usually live in four-room apartments (living space 60-80 m^2). Their average pay is from 1000 to 1500 rubles.

Rumors that communism still prevails in the city are without validity: the same lines at the stores, counters empty by evening, for example, at the vegetable counter cranberries are 20 rubles per kilogram....

Here there are no streets, the houses differ only by their house numbers; the lakes are also designated by numbers.

Guarding the rest of the "subjugators of space" is a special "Zvezdnyy" detachment of militia. And although the area is surrounded by a high fence 10 kilometers long there is plenty of work for the "space gendarmes": both fights and thefts happen, for example, recently the windshield was stolen from the smart Peugeot of a French cosmonaut arriving at the Training Center. In short, in our way of thinking, a city like any other city.

And about politics: as it was made known to us from reliable "local" sources, soon after the coup there was a "de-Partyization" of Soviet "space."

This is the way it was. At the last Party meeting everyone—both the cosmonauts and the instructors and the servicing personnel—were handed registration forms and Party membership cards and told: "Register by your place of residence, if you wish...." But no one displayed any special wish to reenroll in the CPSU.

News of day-to-day life. Now from the life of the space "stars."

Our conversation with Vl. Dzhanibekov, who holds a singular record: five flights into space.

"We have heard that you are making ready for an around-the-world journey in a balloon...."

"I received an invitation to make an around-the-world nonstop balloon flight from the well-known American balloonist Larry Newman. An unusual system has already been prepared which consists of two balloons: one of them is filled with helium and the other with air. This will enable us to control the flight: to rise or descend as necessity dictates. The flight will take place at an altitude 12-15 km and presumably will last three weeks. Our objective is to obtain new information on the Earth's ozone layer.

"The takeoff will take place in a couple of weeks in Ohio. The crew will consist of me, American and Japanese balloonists. Our trajectory will pass over the Atlantic, then over Europe, then Sakhalin and again the States.... The expenditures on this program have already exceeded 4 million American dollars."

"Aleksey Arkhipovich, they say that they want you to retire. Is that so?" we asked flier-cosmonaut A. Leonov.

"Twenty-three years ago, immediately after the death of Yuriy Gagarin, I was named deputy chief for flight and space training. During this time I established a "school," of which I am rightfully proud. But tomorrow I evidently will conduct my last flight critique.... Why they want me to retire so much, speaking truthfully, I do not understand. After all, I am only 56 years old and many of my colleagues are far older than I. I am a military man: when they say that it is necessary to go it remains for me only to obey the order. As my successors I would like to see my old friends: G. Titov or V. Dzhanibekov. What awaits me, for the time being I do not know. I think that I will be able to find work associated with space. And one of these days I will go to America, to San Diego, to the Soviet-American Exhibition of Space Artists. Thereafter we'll see...."

Conditions at Baykonur Cosmodrome Criticized, Kazakh Policy Blamed

Chaotic Conditions at 2 October Launch

927Q0032A Moscow KRASNAYA ZVEZDA in Russian 20 Nov 91 First Edition p 4

[Article by A. Ladin, colonel, KRASNAYA ZVEZDA correspondent: "Show at the Cosmodrome"]

[Text] An episode from the early 1970's comes to mind. At that time I, a newly beginning worker on the newspaper of the Central Asian Military District, expressed my desire to visit the Baykonur cosmodrome. I very much wanted to at least take a quick look at how manned rockets were launched. My visit did not materialize. Grown wise by life experience, my senior colleagues talked me out of it: the cosmodrome has no patience with intruders; there is so much to do there that every man must be on his toes. Do they have spare time to look after outsiders when a rocket is being launched?

Imagine how those colleagues of mine from long ago would react, with that visualization of conditions at the cosmodrome which people had 20 years ago, if I told them what I saw at Baykonur this year, especially on 2 October when a Soviet-Austrian crew was launched. They would regard me with my "pictures" as a lunatic.

I would very much like to form among the majority of the readers resolute hostility against what is going on

today at the holy of holies of the Baykonur cosmodrome—our national pride. But I doubt that this will occur: already very frequently, when there is a conversation today concerning the loss of various properties, about social changes which are not in a better direction, you hear from different people, at times proclaiming their high intelligence and patriotism, the little expression which is so popular at present "So what?" They say, it's no big deal. And in essence, "let it go to blue blazes, it's not my problem."

The estrangement of society has gone to such an extreme that beginning with the leaders of the country and the sovereign republics and ending with the rank-and-file citizen, all are being consumed by the infection of indifference, isolation and a devil-may-care attitude toward their fellow countrymen. As long as things are going OK for them.

And indeed only recently it was a great country. Over the decades such valuable state properties as the Baykonur cosmodrome were established jointly by the fifteen republics, which would not have been established by any one of the now sovereign republics separately. I foresee that after these words we will find people who as usual say: "So what?"

Hearing this each day, one would hope that the entire country would suddenly take heed and respond to my call to hang on to the Baykonur cosmodrome as long as it has not become a graveyard of the once leading thought of the Soviet Union. You agree that there is reason for doubt. And nevertheless I have hopes. From our readers I am awaiting at least a small sign of support. Letters, postcards, telegrams.

So that then, in the early 1970's, I could not visit the cosmodrome. I suppose that someone will interpret this recollection of mine as a wish to put a lock on the cosmodrome. Absolutely not. Moreover, the cosmodrome must be in constant communication with the people. There should be guests here. And let that be true every day. But I am convinced that it is impossible to transform this enormous scientific-production complex into a sideshow, a country fair, a place for holding entertaining shows for the flourishing of independent television and radio companies. If all this was in Leninsk city, there would be no problems. But when literally twenty paces from the command point of the cosmodrome measuring complex tents are set up for dispensing refreshments and intoxicating beverages, when persons who have drunk a bit too much are going about searching for places marked with the letters "M" and "Zh" ["men" and "women"] and are trying to glance into the underground bunker of the control-measuring complex, at the entry not encountering either a guard or a duty officer, pardon me, that's confusion run rampant.

I am not against people naturally and sincerely expressing joy at everything which is good which occurs in our life. And the flight of a Russian, a Kazakh and an Austrian in one crew is a wonderful reason for expressing delight with both the courage of these people and the greatness of Russian science, our machine building, instrument making, rocket construction and other branches which have not yet collapsed. I am all for joy expressed in a civilized way, that people can express joy without interfering with the work of others, without creating dangerous situations for the life of cosmonauts and the fate of future space programs.

Am I spreading it on pretty thick? Believe me, I'm not.

On 2 October the cosmodrome pad from which the universally known Gagarin launching took place was literally jammed with cars, trucks and buses. The people arrived in multitudes. The pad consists of the command point and a great many other structures, from which, as Colonel G. Dmitriyenko, who heads the measurement center told me, tests of carrier rockets are carried out prior to launching and in the process of launching a spaceship into orbit. Here also television information is received from and sent to a spaceship. The cosmodrome complex is linked to a whole network of measuring stations along the trajectory on which space vehicles are put into orbit. Hither flows all the information on the motion of a vehicle put into orbit, crammed with costly electronic equipment. And I say that for the time being I have seen all this only here.

Anyway, among these structures, near the fountain, swarmed the most motley crowd, several hundred persons. From all the republics and from abroad. The situation in actuality was like at a country fair. They drank, they ate, they threw cigarette butts anywhere they fell, tramped on bundles of cables which, it is entirely possible, constituted the very strand which connects a spaceship to the measuring complex. No one in any way restrained themselves. The people arrived to enjoy themselves and did so in spades.

Never before earlier had I seen so many unsober individuals of the most different ranks as on this unforgettable day of 2 October. And where—in the holy of holies of the cosmodrome. So that, looking upon all this bizarre picture, can it be said, as some insist, that things are better? That the people, organizing the show with intoxicating beverages, with camels grazing on the grass on the control point lawn, are burdened with very great concern that some accident might interfere with the cosmonauts returning live and well from orbit?

I was surprised at the attitude of the military leaders also witnessing the throng and confusion. These were extremely highly-placed generals from Moscow. They stood at some distance, to one side of the guests (and the guests came from almost all the republics) and put on a face that everything was normal. They explained to me: this isn't the first time this has happened and everyone has become accustomed to it.

There's no way of telling to what degree the people in positions of responsibility at the cosmodrome on that

morning of 2 October were distracted from their immediate obligations related to the launching of the spaceship. Some gave an interview and others looked out for their superior officers in order to please them and still others, and there were an especially great number of these, were positioned on the cosmodrome roads as sentries, at the most important crossings from structure to structure, watching to see that the very idle guests did not inflict damage.

I thought: and if suddenly something unforeseen happened and it was necessary to immediately make a necessary decision, how much time would be lost by the people who, without distraction, had to take care of the computation work at the launch pad and at other places. It only remains to sigh, deploring that at times when things are going well no one thinks of emergency situations.

Someone will reproach me for being the voice of doom. Then, as an argument, I say to you, relative to vigilance, how order is understood by L. Ter-Petrosyan, president of Armenia, for example. Both in Alma-Ata, in the Palace of Friendship, and at the cosmodrome, in the general throng there was an ever-present group of young men in dark suits and white socks, well outfitted, supplied with compact radio sets for routine communication. And the president of Armenia was not ashamed on this score. Life is more precious than prejudices. Who at that time was ashamed to ensure the reliable safeguarding of the facilities at the information measuring center? Who was ashamed to say, or more correctly, declare, that near the command point there can be no spots for selling food and drink and no room for completely out-of-place people and that all this should be moved beyond the limits of the space complex facilities? Or is the only difference that "life is mine" and "the cosmodrome is ours?"

And possibly acts of licence at the cosmodrome are increasing precisely because the Ministry of Defense is simply ceasing to be the real master here. And when several people are trying to be in command there will really be no order. And if I somehow am able to convince the readers that this is inadmissible, specifically, an absence of authority or multiauthority there where unanimity is required, I think that it is understandable that there is reason to be alarmed for the fate of the cosmodrome.

A French correspondent asked me: "Is it always like this here at Baykonur?" Believe me, this question caused me shame. I was silent. Then he answered himself: "It's not like this with us in Paris." I know that this is not the case. And there where the French launch their Ariene rockets it surely is not this way. And among the Americans, enduring the Challenger tragedy and who learned much after this, it also surely is not the case.

But with us it's all the same old thing, in the worst variant. We are awaiting something which will force us to believe: it is impossible to let everything go to pot where everything usually conforms to order and discipline in the name of success.

Response by Ministry of Defense Officer

927Q0032B Moscow KRASNAYA ZVEZDA in Russian 20 Nov 91 First Edition p 4

[Article by M. Arkhipov, lieutenant colonel, senior press service officer, Space Units, USSR Ministry of Defense: "A Necessary Postscript"]

[Text] As indicated by the article by Colonel A. Ladin, a sort of dual authority has come to pass at Baykonur: on the one hand, nationalization of Soviet-owned property by the government of Kazakhstan, and on the other hand, all the military and space equipment remains under the authority of space units of the USSR Ministry of Defense. I think that there is a need to speak only of the "spectacle" with a clearly expressed local color.

Clearly understanding the significance of unique space facilities for the entire country and the responsibility for their functioning in the event they are taken over by the republic (prior to April of this year the cosmodrome was valued at 3.5 billion rubles with annual expenditures more than 400 million rubles), the government of Kazakhstan already proceeded to its "conquest" last year, as a "Trojan horse" starting up at Baykonur an "independent" television company "Aziya-TV." "Aziya-TV" made itself known by forming among the people the opinion of a key role and place of the republic in the space activity of the country, by organizing receptions of foreign guests and by admitting to the cosmodrome tourist groups formed in Alma-Ata. It became one of the principal organizers of the holiday dedicated to the 30th anniversary of man's first flight into space.

I doubt that the directors of NASA would allow putting on such shows at Cape Canaveral. In contrast to the practical Americans, we in our poverty and unhealthy political situation allow ourselves to organize a "feast amidst a famine." The cosmodrome is precisely an attraction which draws foreigners to itself and yields hard currency. Accordingly, the TV company plans also include the restoration of the famed "Silk Route." As is well known, it did not pass through the territory where the cosmodrome is now located. But by extending it there today it will be possible to reach to the countries of the Near East and gain significant foreign exchange. But for this it is necessary to become master of the cosmodrome

While nationalizing today at Baykonur the public facilities, the trade network (including miliary trade) and industrial enterprises, none of these requiring additional capital investments, Kazakhstan leaves outside the sphere of its claims the central heating facilities, urban communication services and the milk and bread industries, which are operating with interruptions. In other words, everything which is a burden rather than the pride of the cosmodrome.

K. Sultanov, the minister of press and mass information of the republic, declared: all launchings will occur with the accreditation of journalists through his ministry. The right of Kazakhstan to the cosmodrome was confirmed by the first deputy prime minister Ye. Yezhikov-Babakhanov, supporting his statement by a decree by President N. Nazarbayev and with words to the effect that more than 35 years of exploitation of age-old Kazakh lands constitutes payment for the cosmodrome. The directors of the plants of Baykonur received notifications from local soviets in which it is stated that "...in accordance with the decree of the president of the Kazakh SSR of 31 August 1991 No 410... the enterprise under your direction passes to the ownership of the Kazakh SSR. Existing inventory is the property of the republic..." Precisely for this reason, despite the declaration by N. Nazarbayev that the cosmodrome remains under the jurisdiction of the Space Units of the USSR Ministry of Defense, the show, by no means originating with the military, is continuing to this day.

Soviet-French Meeting Confirms 1992 Joint Mission to Mir

927Q0033A Moscow IZVESTIYA in Russian 9 Nov 91 Union Edition p 6

[Article by Yu. Kovalenko, IZVESTIYA correspondent, Paris: "Space Ticket at Cost of 72 Million Francs"; the first paragraph is the source introduction]

[Text] A space ticket with a cost of 72 million francs, such is the sum which the French will pay for participation in the joint (third in number) space flight in the Soviet Mir station, which will take place in the summer of 1992. The cost of a "ticket" for the next journey into circumterrestrial space, in all probability, will increase appreciably.

It was precisely financial matters to which appreciable attention was devoted at the 27th meeting of the French-Soviet Space Commission which was held in Tours. The colleagues of the first French cosmonaut, Jean- Loup Chretien, not without nostalgia probably recall the "good old days" when the Soviet Union twice gratis gave them a place on our ships.

Other times, other ways of doing things. Leaving aside the payments due us, at Tours the talk was primarily about continuing joint research. The dates of the third flight, given the name Antares, were finally determined; it will last two weeks. That will be late July-early August 1992. For the new expedition Michel Tononi and his stand-in Jean-Pierre Znere are training together with Soviet cosmonauts at Zvezdnyy Gorodok.

In the opinion of scientists of the two countries meeting at Tours the implementation of the extensive program of scientific-technical research is entirely satisfactory, and "even better than might be expected."

The French side again confirmed its intention to cooperate with us and the CNES is proceeding on the assumption that the fourth joint flight will take place in 1995-1996. Judging from the reaction of D. Sacotte, the prospects for an increase in "space fares" does not intimidate the French.

They are concerned primarily not with the financial-technical aspects of the program, but by the political aspects, in particular, the future of the Union and what republics in the long run will be included in it. However, for the time being the French participants in the meeting at Tours, headed by J.-L. Lyons, president of the CNES, as noted in the newspaper FIGARO, in addressing his colleagues, preferred to speak not of the Soviet Union, but of "our country."

Almost all the laboratories and scientific centers with which the CNES maintains relations are located in Russia and the Ukraine, whereas the Baykonur cosmodrome, as is well known, is in Kazakhstan. "We sense," says D. Sacotte, "the striving of scientists to establish an association or federation of these republics for joint scientific activity."

Expressing firm readiness to continue cooperation with us, in particular, in the field of telecommunications, Paris at the same time is advocating participation of the Soviet Union in general European space programs.

In this connection the newspaper LE MONDE writes that during an intergovernmental conference which is to be held in November 1991 in Munich, a space program will be drawn up which provides for broad participation of the Soviet Union in it.

Meanwhile the two countries are successfully cooperating in the development of a long-range program for studying Mars. It provides for the launching of two space probes—evidently in 1994 and 1996—for investigating the atmosphere and surface of that planet. They will carry French instrumentation and also a vehicle of the famous Lunokhod type.

Colonel Addresses Russian Deputies on Space Program, Republic Role

LD0410231991 Moscow All-Union Radio First Program Radio-1 Network in Russian 1738 GMT 2 Oct 91

[From the "Parliamentary Diary" program presented by Lyudmila Semina]

[Text] The Soviet of the Republic has listened to a report on our space program, as the deputies were insisting. Colonel (Piskunov), a member of the Committee on Communications, Information Technology, and Space, was given the floor. It was interesting information.

[Begin (Piskunov) recording] I will allow myself to remind you that the Russian leadership and president have spoken on more than one occasion in favor of reexamining the amount and direction of expenditures

for space projects while maintaining the all-Union perspective on space programs. The development of events, however, has uncovered evidence of the unpreparedness and lack of willingness of the majority of republics to finance all-Union space projects.

On the other hand, a tendency to nationalize the space programs is appearing. At the initiative of the Kazakhstan president, the Baykonur Cosmodrome has been declared republican property, the Union-republican program entitled "Kazakhstan Space" has been confirmed, and a republican agency for space studies has been created. An Azerbaijani space program is being developed, and a Council for Space and a republican institute of space studies have been created under the president. The Ukraine has declared a number of projects in the Union program to be republican projects, and Ukrainian representatives are actively participating in the work of the UN technical subcommittee for space.

At the same time, it is well known that the main burden of the expenses involved in implementing the Union space program is borne by the Russian Federation. This situation requires a reexamination of the position and policies of the Russian Soviet Federated Socialist Republic [RSFSR] in terms of the all-Union program and property and forms of management in the space industry. The majority of the design installations are on Russian territory, as are most of the scientific research institutes and space industry enterprises which consume the major portion of state expenditures on scientific research institutes for space rockets and projects which often seem dubious from the point of view of Russian interests.

Russia has the world's most overloaded cosmodrome, Plesetsk, the creation of which demanded hundreds of millions [currency not specified] in outlay. Statistics on rocket launches over the last 30 years shows a one and a half-or two-times greater increase in the burden assumed at Russian cosmodromes in comparison with the one at Baykonur. Veterans had this saying: Baykonur works for TASS, Plesetsk works for us.

The Plesetsk Cosmodrome is the main—but not the only—testing ground in Russia for developing missile systems which form the basis of our country's nuclear missile parity. Thus Russia bears the main expense for both implementing the space program and ensuring the USSR's parity in nuclear missiles. It is inevitable that we would feel the serious material, ecological, and moral expenses.

Over the years the Defense Ministry has taken around 10 million hectares of Russian land for cosmodromes and bases for rocket stages falling back to earth. Over 30 years, more than 1,000 rocket stages and other major disconnecting parts containing hundreds of tonnes of highly toxic rocket fuel components have fallen on this land. The number of tests of military missiles and satellite launches has inevitably had an effect on the ozone layer, leading to the formation of ozone holes. All of this, along with social and economic problems, leads to a growth in social tension in the local population and even to the threat to blockade cosmodromes, strikes, and other forms of mass protest. [end recording]

We also heard such details as the Kazakhstan president obtaining a plan for a special space program—Kazakhstan Space—from the Defense Ministry. It was also said that, while keeping Baykonur as the property of Kazakhstan, the republican leadership—as can be concluded from today's TV reports [on the launching of a Soviet-Austrian crew from Baykonur]—is counting on a continuation of the volume of Union investments for its development. As an alternative, there is a possibility of transferring the cosmodrome's territory and equipment to foreign states. But this, as they say, is conjectural information, information to ponder.

The deputy summed up the report by saying that the situation clearly requires the development of a concept for a national space policy, an RSFSR law on national space policy, and proposals for Russia's modes of participation in the all-Union space program. Drafts on these ideas will be presented to the republican leadership in the very near future.

Lack of Financing Jeopardizes Space Enterprises

LD0601042992 Moscow Russian Television Network in Russian 2100 GMT 5 Jan 92

[From the "Vesti" newscast]

[Summary] Republics of the Commonwealth of Independent States have agreed to carry out joint space research, but Ukraine and Moldova are in no hurry to finance space programs. According to some estimates, the money available for space research will run out this spring.

Conversion was the first serious blow to the country's space industry. "A total of 60 percent of orders received by the space industry were from the military. Last year the financing of the industry from the budget was cut by 700 million rubles." As a result, programs that have been started are not being completed and space industry enterprises are being shut down. "According to experts, this industry may completety cease to exist in three to four months. The bulk of financing for the 7-billion ruble space program is from Russia."

S. Zhukov, a member of a working group on cooperation in space, says that the most important thing at present is to set up a Russian space agency, since 80 percent of the space science and industry of the former Union is situated on Russian soil.

Suspension of Buran Space Program Urged

927Q0050A Moscow KURANTY in Russian 21 Dec 91 p 8

[Article by Engineer B. Olesyuk: "The 'Buran' Blind Alley"]

[Text] **They bring tour groups here and describe in rainbow colors the "space heroism," committed on 15**

November 1988. On that day, our space shuttle Buran made its first two-circuit flight around the globe. The Buran flight was controlled from this magnificent room. But what is here now is the BURAN BLIND ALLEY.

During the last few years, the Space Flight Command Center in Podlipki, near Moscow, has expanded considerably. A new facility, built specifically for Buran flight control, glitters with the sun reflecting in the countless windows.

The building looks nice from the outside—a combination of concrete, glass, aluminum, and plastics.

In contrast, a large room from which control over the reusable space vehicle flight is done, makes a strange impression—it looks deserted; dead, cemetery-like quiet hangs over it. New control panels with turned-off monitors look like orphans. Only large information screens come on occasionally, and the representation system's electronic display lights up.

This is because during the last three years the impressive room with the modern control equipment has not been used for its designated purpose. By a whim of fate, it was turned into a sort of a museum.

A lot of time and events have passed, but the so-called reusable space vehicle never made a second trip to the orbit. In the beginning of the year, the newspapers were writing that Buran's second unmanned experimental flight would take place in March; then it was moved to December. But this was not to be, either. Why? A sad but, alas, unarguable fact: because of the difficulties with financing, the timing of the next Buran launch is being postponed until December 1992.

Everything related to Buran is idle these days. The vehicle itself, tightly swaddled in covers, stands still in proud loneliness in one of the hangars of a monumental assembly and testing building at the cosmodrome; the giant service gantries at the launch complex are immobile; and the control room at the flight control center lays silent. Also on the cosmodrome, the powerful 170-million-horsepower Energiya booster peacefully "dozes" on its immense erector cradle.

What happened to it, this space aircraft? What is its "transgression?" Some say that, to put it mildly, we have tripped over our own feet with Buran; others are inclined to believe that we have fallen flat on our face with it. I would put it in even harsher terms: A serious strategic miscalculation has been made. Our winged space vehicle has not withstood the trial of time, while the space agency, represented by the currently defunct Ministry of General Machine Building has suffered a complete fiasco.

At this point, reasonable questions arise right away. Why was Buran built? Who made such a fateful error? And, in general, how did this precipitate idea come to life in the first place? It is difficult to establish now who was the first one to say "eh." There is, however, this tale. Leonid Smirnov, former VPK [military-industrial complex] chairman and a member of the same Dnepropetrovsk team, in his regular report to Brezhnev on the state of our space efforts, once mentioned in the end: The Americans are intensively working on a winged space vehicle. Such a vehicle is like an aircraft; it is capable, through a side maneuver, of changing its orbit in such a way that it could find itself at the right moment right over Moscow—possibly with a dangerous cargo. The news disturbed Leonid Ilyich very much—he contemplated it intensively, and then said: We are not country bumpkins here. Let us make an effort and find the money.

Thus, from a talentless manager's serve, an erroneous decision was made by the general secretary. Made by one man with immense power and shallow mind, and on top of that not possessing even elementary knowledge of space issues.

Of course, nobody dared to contradict "No. 1." The VPK leadership took the instructions from the four-times Hero of the Soviet Union as gospel. In the documentation, the idea of creating the Buran is justified by the necessity of maintaining military-strategic parity with the Americans. Another person who was successfully pushing this concept was then Central Committee Secretary D. Ustinov, in charge of defense and space issues. Once again, economic interests were sacrificed on the altar of political expediency.

At the price of immense effort by the entire nation—after all, 80 percent of the national scientific potential works for the VPK—the task was indeed accomplished. Unlike the Americans, it took us 14—rather than nine—years, although we were traveling along an already beaten path. It took a long time to resolve the problems of the oxygen-hydrogen engine on the second stage of the Energiya booster; there were many other problems. Plus, the Buran technology is far from simple. For instance, it took two years of painstaking, intricate work to glue the tens of thousands of heat-insulating ceramic tiles on the vehicle. For fairness sake, our scientists, engineers, and workers who participated in the creation of the Buran-Energiya system, should be given their due credit. In incredibly difficult conditions, they overcame an immense number of problems and fulfilled the task. Nevertheless, sad as it is, nothing good came out of it, and could not. Expenditures on the vehicle turned out to be unjustified.

Buran's first flight was a success; it also caught everybody unprepared. A key problem arose: How to use the vehicle in the future? No matter how they looked at it, they could not find any civilian space payload for Buran. In 1974, when the work was started, this grandiose project had been seen as a military program. Later, our Pentagon rejected it as holding no future promise.

The people have a moral right to know what the Buran program cost, and how much more needs to be invested

to bring it to its logical conclusion. There is an answer to part one. During its 17 years, the program has swallowed over 17 billion rubles [R]. And the result? Zero. Plus, I have grave doubts about this figure—I do think that the numbers had been fudged.

In 1989, for the first time during the space era, our parliament dared to announce the amount of expenditures on the space program: R6.9 billion. Can one accept this figure on faith? Of course not.

In 1989, the USSR sent 100 apparatuses into orbit; the United States sent 24, Europe sent 10, and Japan sent two. Simple arithmetic shows that the Soviet Union had launched three times as many space objects than the rest of the world combined. What are the real expenditures? By American experts' estimates, in 1989 the USSR spent $33 billion (at the 1989 exchange rate) for its space program; the United States spent $30 billion, and Western Europe—$2 billion.

Using the partocratic language, our plans in the 1970's were of truly revolutionary scale. We were dreaming of building five reusable space vehicles—as the Americans had done—and thus achieve complete strategic parity with them. However, we have to acknowledge with sadness that at this point for all practical purposes we do not have even one working vehicle.

We have driven ourselves into a blind alley. Let us try to sort out this problem. It is time to understand a simple truth: Our scientific and technological lag in relation to developed countries in the West is based on our lag in all other areas. The situation with Buran is convincing evidence of that. To consider our space shuttle a serious success of our space research is—forgive the pun—just not serious.

We have spent 14 years building the Buran, only to find out that it is unfit as a reusable vehicle. It is unbelievable but true: The vehicle received a certificate of flight fitness for just one atmospheric reentry. What is the reason? It is not enough to build a shuttle; one needs a certain quality metal for it. Right now, the vehicle is going through qualifying testing for a standard use of up to 25 times (the Americans use theirs up to 100 times). We do not know how many flights the Buran's cruising propulsion unit is designed to handle. As the first flight indicated, the heat insulation problem seems to have been resolved: of the 39,000 heat-insulating tiles, only four had fallen off. A second prototype—Buran-2—was being built for the second flight, but it is not completed yet.

Our space vehicle went through its space "baptism" only once, and in an unmanned mode at that. Let us ask ourselves a question: Do we have a right to call the Buran-Energiya system reusable? The answer is clear: No.

The best way to approach the truth is through comparisons. The Soviet Union is always in the position of the one catching up. In engineering language, it is in a permanent phase lag. Our designers are simply being overcome with this unbounded desire to travel again the road the American space researchers used 10 or 15 years ago. Our Buran is nothing other than a morally obsolescent analog of the American orbiter, its poorer version.

There are many who are still caught in the web of false perceptions and myths. Being several orders behind the United States by many economic indicators, we are carrying a burden of space-related expenditures that is incommensurate with our potential. The starting point of the Buran road were the leaders' ambitions, various considerations of prestige, and the "great power" policy.

Let us be objective and principled. Of the entire Buran-Energiya system—and even this stretches things quite a bit—only the vehicle itself (and this still needs to be proven) may be identified as reusable. On the orbiter, all components of the booster system are saved, with the exception of the fuel tank. Their space fleet of orbiters has made over 40 space flights.

The Buran delivery system—the Energiya booster—is a expendable device. This circumstance makes Buran flights much more expensive. Thus, a conclusion is begging to be reached: From every economic angle launching the Buran-Energiya system is not profitable. The Americans manage to prepare their shuttle for the next flight in two to three months; for us, three years has not been enough to send our Buran on a second trip. In short, no matter where you look, there is a problem there.

By the way, on the topic of economic effectiveness of reusable space vehicles. The American engineers committed an unforgivable mistake. Their calculations were not borne out in practice. For instance, the cost of lifting 1 kg of cargo into orbit is $9,190 on a Titan-4 booster, while on the orbiter it is more expensive—$9,750. The designer—Cosmonaut Feoktistov—wrote about this hopeless matter at the time, but nobody took his prediction into account.

Now the moment has come when economics takes us by the throat and forces us to revise the entire space budget. So now we have come to the most important and major question: What are we to do with Buran? Is there a sensible way out of the blind alley? I dare to maintain that it is madness to continue with Buran under current circumstances.

Some propose to close the program; others—to freeze it until better times. In the current situation, we need a sensible, sober, weighted approach. What is the least painful way out? It is acceptable to mothball Buran, but it is not acceptable to close the program outright, as was done at the time with the superpowerful N-1 booster. I personally lean towards the idea of mothballing the vehicle. We are no longer talking about prestige here, only of the need to prevent the already spent billions from being thrown out in the wind.

The Energiya booster is at the very beginning stage of flight testing. How will it behave in the process of subsequent flights? We do not know it, but there are already serious warnings. It is known that an intermediate booster Zenith was built on the basis of the Energiya lateral unit and uses this lateral unit as its first stage.

Specialists have already discovered hidden and very serious defects that became apparent in the process of Zenith exploitation and have led to two boosters exploding during the first few seconds of flight. This is a very serious signal. Alas, four years later, everything has come a full circle: The testing of Energiya has to be restarted from square one.

Semenov Defends Space Programs, Buran Shuttle

927Q0048A Moscow PRAVDA in Russian
24 Dec 91 p 6

[Interview with Yuriy Semenov, chief designer of Energiya scientific production association, by TASS correspondent Rena Kuznetsova, especially for PRAVDA; place and date not given: "Yuriy Semenov: 'So Far, Common Sense Prevails'—Conversation Aboard the Flight From Baykonyr"]

[Text] **Under the airplane wing is the Aral Sea—begging for help, hopelessly damaged. Truly, "humankind has only one executioner—itself." And what will be the fate of the Baykonyr cosmodrome? This was the first question in our conversation with Yuriy Semenov, chief designer of Energiya scientific and manufacturing association.**

[Semenov] Baykonyr is our main spaceport. For decades, this is where they created the most sophisticated systems for assembly, testing, prelaunch preparations, and launches of space vehicles and rockets. There is a powerful manufacturing and transportation support infrastructure. There are residential areas with housing for thousands, where workers and specialists live in the harsh semidesert conditions. Any decisions on its future use should be made collectively, on the basis of a comprehensive analysis of circumstances and the opinion of all interested parties.

Unfortunately, there have been many hasty judgments and unfounded proposals lately. So far, common sense and sober appraisal have prevailed over the emotional intoxication, and our work still has not been disrupted.

In many respects, the cosmodrome's existence has changed life in this region for the better. Use of space methods has permitted a better understanding of the situation in Kazakhstan's environment and has produced recommendations on how to change it for the better.

This is the current purpose of a comprehensive program "Kazakhstan-Kosmos." I think that the announced decision to create in Kazakhstan a special agency for space research and utilization will help development along these lines. In addition, some new technical solutions we are working on are aimed at reducing the restricted land area needed to support a launch. In particular, we are looking at the draft rocket design with guided first stages that, instead of falling down in the steppe, will automatically land at the airfield near the launch area—as the Buran vehicle has demonstrated. The opening up of space cannot be the domain of individual agencies or nations. This is a universal humanitarian cause. Approached intelligently, any problems can be resolved, whether they are technical, organizational, commercial, or political.

[Kuznetsova] According to some reports, space-related expenditures may be cut considerably in the near future. What can you tell in this respect?

[Semenov] Yes, I have seen such statements in the press. At the same time, there is no doubt that human progress is unthinkable without space research. It is hard to find a sensible justification to cut the already modest appropriations for this purpose. Using the language of a market economy, these appropriations are an investment, whose effectiveness is beyond doubt; in no way are they expenditures, losses. It is important for those who call for such actions and those who write about it to remember this.

I would like to particularly underline the point that, unfortunately, it is the most advanced area in the entire space research—work related to manned spacecraft—that is especially vulnerable under the superficial appraisal of expediency that is common now. It will be very sad if the circumstances in our country become such that the size of state appropriations for fundamental research of the universe also starts to depend on the immediate direct effect expressed in real money.

In the past, we have seriously thought about wider involvement of scientists from the entire world in our work. Now it is acquiring special urgency, and we need to look for realistic options to work in this direction in the new, changed conditions. Many enterprising scientists and businessmen in a variety of countries want to conduct work in space but do not have the necessary technical base. Therefore, at this stage our task is to turn the Mir orbital station into an international laboratory.

[Kuznetsova] Please tell us about upcoming international projects on commercial basis. What are the real benefits?

[Semenov] We have been participating in international cooperation for 15 years. There are many examples of jointly using unique equipment developed through joint programs at the station. Commercial projects provide an opportunity for bringing hard currency into the country, thus providing additional financial support for the space program. As to the scale of the contracts, I can only tell that it is in the tens of millions of dollars.

[Kuznetsova] The figure lately being mentioned in the mass media in regard to defense expenditures is 25

percent of the gross national product. Can you tell what the real situation is in this respect and in regard to space research?

[Semenov] It is true that fulfilling a number of defense tasks (to be precise, remote observation and control over the compliance with disarmament agreements) traditionally had been a major part of research conducted from the space stations. Money appropriated for these purposes made it possible to develop optical instrumentation and methods of work that can be used for the ecological and natural science observations that are so important today. On the other hand, a certain impression of broad involvement in defense work is the result of the fact that the Baykonyr cosmodrome, the cosmonaut training school, and the network of ground tracking stations are a necessary part of it. The personnel who work there are military people; their pay comes from the military budget. I think that neither the former nor the latter should not convey a false impression of the militarization of our space research.

[Kuznetsova] Yuriy Pavlovich, can you tell us please what conversion is? For our people, for an individual—is it really a good thing? After all, the operation of the military-state machine, this "monster," is still hidden from us behind a shroud of secrecy.

[Semenov] Of course, in my view conversion is for the better. At the same time, it does not mean that a cosmonaut should become a pastry chef, or a chief designer be retrained as a cobbler. We see conversion first of all as a desire to use space-related means for the good of the humanity. I have already mentioned some of such projects; there are also others. The special features of our experimental plants and the talent of engineers and workers allow us to boldly undertake new unique tasks. A typical example: The achievements of technology built for the defense sector may be successfully used for major communications centers and fundamentally resolve the problem of information delivery in society. This is a working conversion that uses all our industrial and intellectual potential.

[Kuznetsova] "The Kaluga Dreamer"—K.E. Tsiolkovskiy—predicted that space would provide "mountains of bread" and "unlimited power" for humanity. As it stands today, the first part of the prediction does not hold water, to be honest.

[Semenov] You know, life has shown us more than once the danger of deferring to classics and founding fathers. The world has changed drastically since K.E. Tsiolkovskiy's times. Combining the efforts of all countries, coordinating all work, and concentrating the thought of all specialists is the way to create a truly powerful humanity. In this case, there is no need to draw the line of the permissible. As to the "mountains of bread," why does it not hold water? Space has opened new opportunities for us. Is a one-of-a-kind ability to tie continents together not bread? Or are not communications just as necessary for the modern society? Many of the latest events provide an affirmative answer to this question.

Of course, many quoted numbers on the effect of space research are just as much an assumption as the thousands of diggers replacing an excavator in the school arithmetics textbook. It is impossible to demand an immediate direct return from space research—as, by the way, from any other complex and energy-intensive field. Moreover, the happenings on the front line of science have never been recognized as pragmatically usable even by their inventors. A widely known example is that of Hertz and electromagnetism. The same may be said in regard to space technology. I think that even S.P. Korolev could not imagine at the time when the first sputnik was launched all the capabilities that we now cannot do without.

[Kuznetsova] As we are lately finding out on Earth, we are going—to put in mildly—in the wrong direction. As a chief designer, can you sincerely say that we have avoided this mistake in space?

[Semenov] Of course, as in any new business, there have been mistakes in space research, too; there have been tangible losses and human casualties. Not as many, however, as your colleagues have been describing lately. We have nothing to hide. All our failures are officially known. But there have also been noticeable successes and considerable achievements. The most important part is choosing the right road, the main direction, a goal. In this, I think, we have not made a mistake, as well as in choosing the development of orbital manned stations and the research conducted on them. Today it is obvious that the conditions of flight permit the implementation of the technologies of tomorrow. Nor have we made a mistake in choosing the strategy of building a heavy transport system—Energiya-Buran. The powerful vehicle can provide a solution for global problems for all humanity: influence in a beneficial way the atmospheric ozone layer, remove radioactive waste from the planet, or provide light to polar regions. All of this requires powerful equipment which we already have.

[Kuznetsova] I understand that Buran is your pet project. But has it not been standing in the hangar for too long? Is it not too costly?

[Semenov] Creating a vehicle such as Buran is a large undertaking. It is a complex task, literally at the edge of technological thought. Of course, it is an expensive idea by itself, but it is justifiable as a methodical step towards the means of transport of the next century—cheap, ecologically clean, and effective. As a means of transport for our program, Buran is somewhat ahead of schedule in the development of the future orbital system where it will be irreplaceable. As to it gathering dust in the hangar—let me assure you as a specialist that we are preparing the vehicle for its next flight. The work is proceeding in accordance with the program that does not envisage as frequent flights as the Americans do because they do not have other capabilities. They have also

arrived at the conclusion now that as a means of delivery it is unjustifiably expensive.

[Kuznetsova] One more thing—as they say, "very personal..." It still remains a mystery to me, an inconceivable twist of fate—the announcement of Central Television that the number one ticket to space among Soviet journalists belongs to me. Putting aside personal emotions, I want to give a reminder that six journalists are being prepared to take off through the Space for Children program. I want to ask: Will there be a time in the foreseeable future when a person, without lengthy and harsh training, will be able to buy a ticket—let us say, through Aeroflot—to an orbital station?

[Semenov] Taking into account our commercial services, one may say that such a time is already here. The fact is, however, that not too many can afford a ticket to space, but I personally do not have much doubt that the preparation for it will be considerably simpler as time goes by. Provided, of course, that we continue the developmental work and keep gaining experience rather than folding the programs.

Need for Russian Space Agency Discussed

PM0901110992 Moscow Russian Television Network in Russian 2100 GMT 5 Jan 92

[From the "Vesti" newscast: Report by V. Skvortsov and S. Murazov]

[Text] [Announcer] It is already known that the Commonwealth of Independent States intends to conduct joint space research, but neither the Ukraine nor Moldova is hurrying to invest resources in the space program. Meanwhile, the money is running out and certain estimates claim that by spring there will be nothing left.

[Skvortsov] Of course, nobody is surprised at the report that our space program is also on the brink of crisis. Conversion dealt the first blow—it was the military which accounted for 60 percent of the orders received by the space industry. Last year this sector's budget allocations dropped by 700 million rubles—programs are being canceled, enterprises are closing, and specialists are leaving. Some experts believe that within three or four months this sector could cease to exist altogether. Russia bears the main burden of financing the 7 billion [currency unspecified] space program. So it is no surprise that Russians have little confidence in the Minsk agreement on the joint exploitation of space.

[S. Zhukov, member of the Working Group for Cooperation in Space] The main thing for Russia now is to create a Russian space agency. Eighty percent of the former Union's space scientific research and industry is based in Russia.

[Skvortsov] It would be a crying shame if we lose one of the few things which our country really can claim to have developed to world standards.

Ukraine Government Claims No Control Over Space Units

OW0801192692 Moscow INTERFAX in English 1839 GMT 8 Jan 92

[Transmitted by KYODO]

[Text] Ukraine will not claim command over the units of space system control, based on its territory, that used to belong to the armed forces of the ex-USSR. An agreement to that effect was reached during a meeting of senior Commonwealth military commanders with Ukrainian leaders in Kiev late last week. Well-informed sources say that the talks were difficult, but that the space force commander, Col.-Gen. Vladimir Ivanov, managed to persuade Kiev of the inexpediency of resubordinating the units in question to the Ukrainian command.

According to the same sources, elements of the general system of control over spacecraft in orbit are based in Simferopol and Yevapatoria.

Omsk Electromechanical Plant Director Cited on Conversion

PM0901141192 Moscow Russian Television Network in Russian 1120 GMT 2 Jan 92

[Report from the "Under the Caterpillar Tracks of Conversion" documentary]

[Text] [Unidentified Reporter] Until quite recently the Energiya-Buran complex would have been called an outstanding achievement of Soviet science and technology. Now no less strident voices can be heard everywhere claiming that we wasted a billion rubles [R] by developing this space system which, it seems, nobody needs. This conflict is a vivid example of what excessive secrecy can lead to—an isolated defense sector and highly important decisions being made behind closed doors by a small circle of people. But even the Energiya-Buran system's most strident critics admit that the shuttle's ability to land automatically was a unique achievement by our scientists and designers. These included workers from the Omsk Electromechanical Plant. The plant developed electronic and electromechanical devices for spacecraft guidance systems. Nowadays we are starting to evaluate the quality of new products on the basis of whether they are able to stand up to market competition. The instruments produced by the Omsk Electromechanical Plant have been tested under even tougher conditions—in space. In the past few years the enterprise has experienced such difficulties that it seems it will be hard for the plant to emerge from the crisis without outside help. That is probably why doors which had previously been tightly shut were opened up for us. Lev Yakovlevich Osipov, the plant's general director, talked very frankly about the problems.

[Osipov] Our first encounter with the word "conversion" was in 1989. When conversion got under way here in the

second half of 1989 we lost around 12 percent of our output. But the plant was absolutely unprepared to compensate for this 12-percent loss.

[Reporter] You just got your instructions from on high and started carrying them out?

[Osipov] Contracts were dropped and orders withdrawn. Then in May 1990 we lost another 18 percent—not 12 percent this time. The picture's been the same as in 1990. We have lost R53 million worth of output in a totally unplanned way. The enterprise has been trying to hang on to its skilled specialists. We managed to keep them in '89 and '90. But by the end of 1991 we were already finding it tough since we no longer have any way of hanging on to people. Basically because outside organizations—cooperatives and small enterprises—are offering better pay than state enterprises.

[Reporter] Of course, the enterprise is not twiddling its thumbs. They have been trying to save the collective and its skills. For instance, they have begun producing the "Mercury" stereo system. The systems are in demand and are relatively complex, so there is hope that the knowledge and experience of the electronics workers will not go to waste. Part of the collective has switched to the production of medical equipment and portable vacuum cleaners. But, of course, the skills needed for this work cannot be compared with those required for spacecraft instruments.

[Osipov] This kind of precision is not found in everyone. People must have an aptitude for the work and be neat and precise people as far as their character goes. Because of conversion we are losing these specialists as well as losing output. They are not getting their salaries or the kind of precision work they are able to do. And their professional ability to do this kind of precision work is being lost.

[Reporter] It seems as though the Omsk Electromechanical Plant should not be expecting any big space-related orders in the near future. But there is hope that the plant will manage to keep its head above water. Although the losses incurred from conversion already run to nearly R20 million. Fortunately, the plant has managed to reposition itself in the marketplace—albeit with some losses.

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